The Impact of Normative Comparison Amongst Colleagues with Regards to Energy Consumption in an Office Environment

Developers

Final version (presented here) by Meredita Susanty and Peer-Olaf Siebers. Based on initial work from Tao Zhang and Peer-Olaf Siebers.

EABSS Version

1.0

Related Publication(s)

- Siebers PO (2017) 'Facilitating Multidisciplinary Agent-Based Social Simulation Modelling: A (More) Formal Approach'. Poster presented at the ABM17 Symposium, 20-22 Apr, San Diego (CA), USA.
- Siebers PO and Klügl F (2017) 'What Software Engineering has to offer to Agent-Based Social Simulation'. In: Edmonds B and Meyer R (Eds). Simulating Social Complexity: A Handbook - 2e.
- Zhang T, Siebers PO and Aickelin U (2011) 'Modelling Electricity Consumption in Office Buildings: An Agent Based Approach'. Energy and Buildings, 43(10).

Focus

Illustrative case study model development and implementation.

Motivation

In this illustrative example we focus on the simulation model development to support studying the impact of normative comparison amongst colleagues with regards to energy consumption in an office environment. Normative comparison in this context means giving people clear regular personalised insight into their own energy consumption (e.g. "you used x% more energy than usual for this month") and allowing them to compare it to that of their neighbours (e.g. "you used x% more than your efficient neighbours"). A simulation study could compare the impact of "individual apportionment" vs. "group apportionment" of energy consumption information on the actual energy consumption within the office environment.

Gathering Knowledge

For our study all focus groups were led by a Computer Scientist and the participants consisted of a mixture of academics and researchers from the fields of Computer Science, Business Management, and Psychology.

Step 1: Define Objectives

Aim

- Study normative comparison in an office environment

Objectives

- Investigate the effects of having the community influencing the individual
- Measure the extent of impact (significant or not)
- Test, if we can optimise it using certain interventions

Hypotheses

- Peer pressure leads to greener behaviour
- Peer pressure has a positive effect on energy saving

Experimental factors

- Initial population composition (categorised by greenness of behaviour)
- Level of peer pressure (individual apportionment vs. group apportionment)

Responses

- Actual population composition (capturing changes in greenness of behaviour)
- Energy consumption (of individuals and at average)

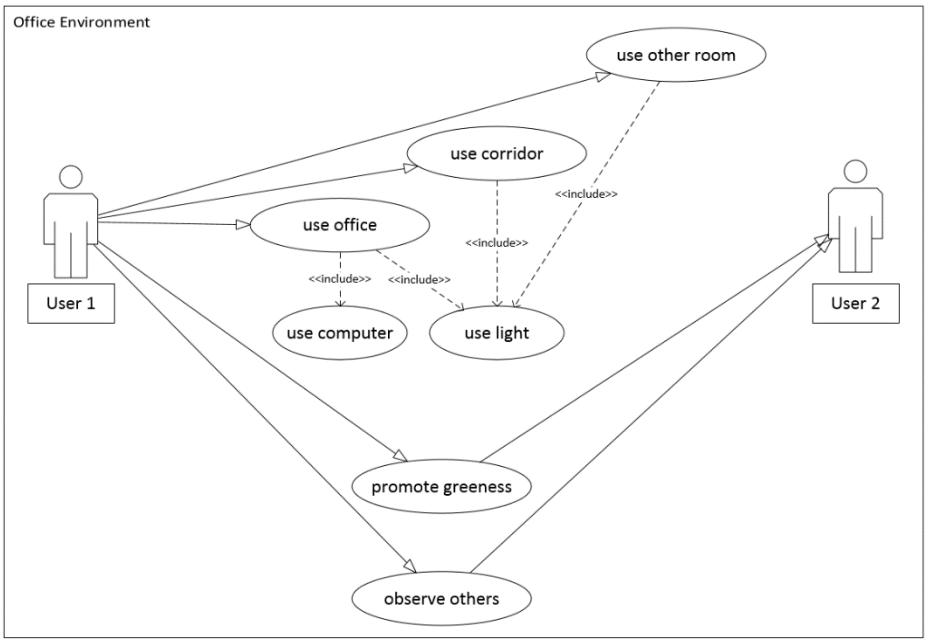
Step 2: Define Scope

Key driver(s): Transparency (but still keeping it realistic)

Category		Element	Decision	Justification
Actor		Staff	Include as group (User)	Regularly occupy the office building
		Research fellows		
		PhD students		
		UG+MSc students	Exclude	Do not have control over their work environment
		Visitors	Exclude	Insignificant energy use
Physical Environment	Appliance	HVAC (Heating + Ventilation + Aircon) system	Exclude	We only need one major energy consumer to test the theory; we decided to go for electricity
		Lighting	Include	Interacts with users on a daily basis; controlled by user
		Computer	Include	Interacts with users on a daily basis; controlled by user
		Monitor	Exclude	Modelled as part of the computer
		Continuously running appliances	Exclude	Constant consumption of electricity; not controllable by individuals
		Personal appliances	Exclude	No way to measure consumption
	Weather	Temperature	Exclude	Not necessary for proof-of-principle
		Natural light level	Exclude	Not necessary for proof-of-principle
	Room	Office	Include	Location where electronic appliances are installed
		Lab	Exclude	Mainly used by UG+MSc
		Kitchen	Include as group (Other Room)	Common areas frequently used by "users"
		Toilet		
		Corridor	Include	Commonly used when "users" move around
Social / Psychological Aspect		Comparative feedback	Include	Effective strategy to reduce energy consumption in residential building
		Informative feedback	Include	Effective strategy to remove barriers in performing specific behaviour
		Apportionment level	Include	Potential strategy to reduce energy consumption in office building
		Freeriding	Include	Behaviour that differentiate two apportionment strategy
		Sanction	Include	Factor to encounter freeriding behaviour
		Anonymity	Include	Factor to encounter freeriding behaviour

Step 3: Define Key Activities

Actor roles and related use cases



Step 4: Define Stereotypes

Based on a survey amongst our school's academics, researchers, and PhD students, anonymously asking them questions about their habits towards work time and energy saving awareness. We then analysed the data through cluster analysis to come up with the stereotype groups, assigned some speaking name and populated the stereotype tables with the "habit" information.

Work time habits

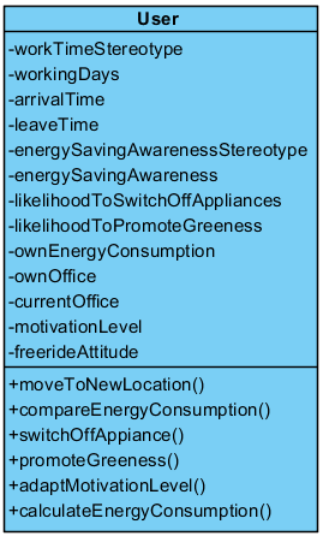
Stereotype	Working days	Arrival time	Leave time
Early bird	Mon-Fri	5am-9am	4pm-7pm
Time table complier	Mon-Fri	9am-10am	5pm-6pm
Flexible worker	Mon-Fri	10am-1pm	5pm-11pm
Hardcore worker	Mon-Fri + Sat	8am-10am	5pm-11pm

Energy saving habits

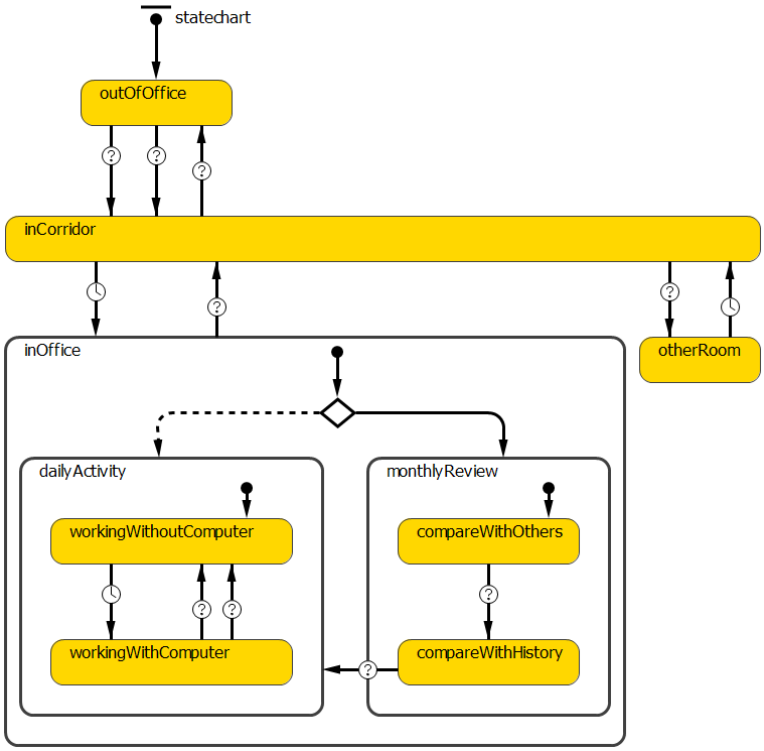
Stereotype	Energy saving awareness [0-100]	Probability of switching off unnecessary appliances	Probability of sending emails about energy issues to others
Environmental champion	95-100	0.95	0.9
Energy saver	70-94	0.7	0.6
Regular user	30-69	0.4	0.2
Big user	0-29	0.2	0.05

Step 5: Define Agent and Object Templates

User class



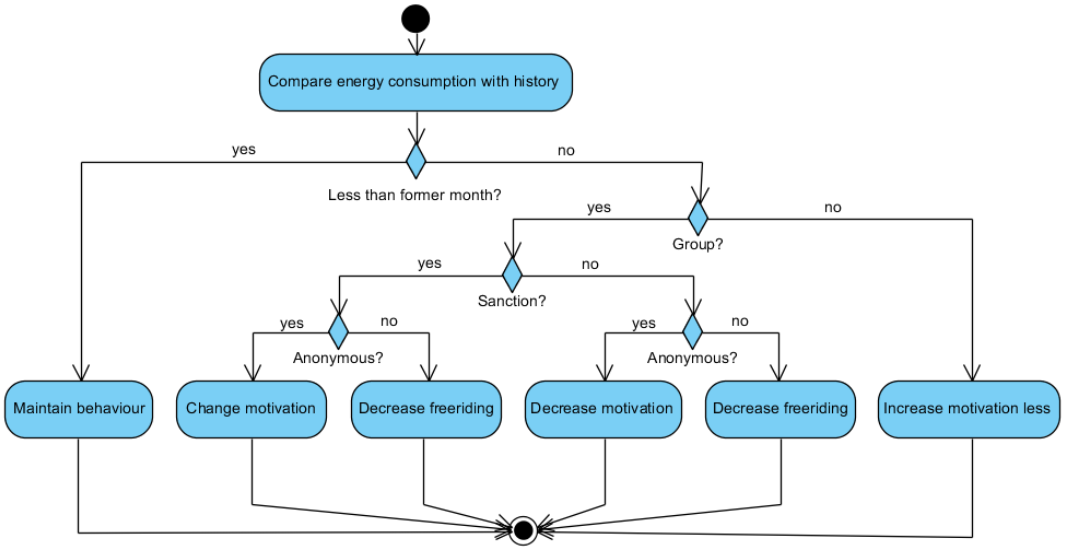
User state chart



User state chart transition definitions (excerpt)

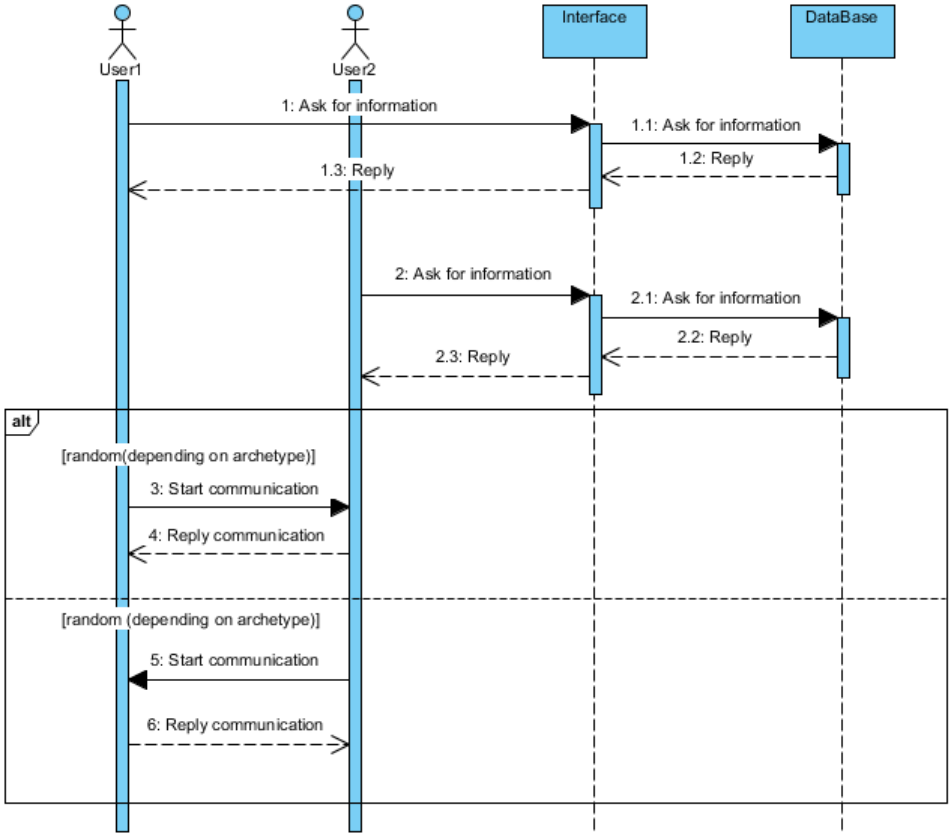
From state	To state	Triggered by	When?
outOfOffice	inCorridor	Condition	At typical arrival time during the working week for all
outOfOffice	inCorridor	Condition	At typical arrival time on Saturdays for hard-core workers only
inCorridor	outOfOffice	Condition	At typical leave time
inCorridor	inOffice	Timeout	At average after 5 minutes
inOffice	inCorridor	Condition	At random while at work or when leaving
inCorridor	otherRoom	Condition	At random while at work
otherRoom	inCorridor	Timeout	At average after 10 minutes
...	...	...	...

User activity diagram



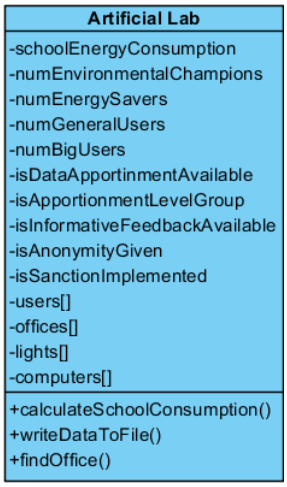
Step 6: Define Interactions

Sequence diagram for the use case "observe others"



Step 7: Define Artificial Lab

Artificial Lab class definition



Implementation

Implementation in AnyLogic