From green norms to policies - combining bottom-up and top-down approaches

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Abstract. This paper proposes and describes an architecture that enables the identification and spreading of green norms in agent societies and the eventual elevation of green norms into policies. Using a real world case study on duplex printing, this paper demonstrates how norms can be identified and also discusses approaches for spreading norms. Using an agent-based simulation study of the energy conservation domain, this paper demonstrates the impact of boomerang effect on norm spreading.

Keywords: Norms, Policies, Green Norms, Agents, Societies

1 Introduction

Top down policy design and execution have been successfully carried out by governments and organizations. However, policies at times result in negative externalities (unintended negative consequences). For example, let us consider a policy gone wrong from the transportation domain. In some states in the United States hybrid car owners enjoyed the privilege of driving solo in the High Occupancy Vehicle lanes (HOV) which were originally used by car-poolers. This led to increased traffic congestion [8]. Additionally, it also led to increased theft of car stickers that signaled the privilege to use the HOV lanes. This policy has now been abolished. A recent study has found that banning hybrid cars from HOV lanes caused congestion for all the other commuters [13]. Scenarios such as this are good candidates for agent-based simulation studies on policy modelling. By employing a simulation study various "what-if" scenarios could have been investigated and potential externalities could have been identified and prevented.

There are two approaches to model policies: the top-down and bottom-up approaches. In the top-down approach, the designer of a policy specifies a policy and the effects are studied (typically in a simulation set-up). This approach may have the limitation of the designer focusing on just some of the key outcomes such as the efficiency of the system (e.g. reducing traffic congestion) without explicitly considering the viewpoints of different stakeholders. Participatory policy making (PPM) addresses this issue by considering viewpoints of different stakeholders [3,12,24]. PPM is increasingly being adopted by organizations and governments

[24]. Policies created using PPM are seen as legitimate, effective, efficient and sustainable [3, 12].

The bottom-up approach to design policies investigates whether there are social norms that address the problem for which the policy is being designed. If deemed suitable, these social norms can form the basis for the policy. An example of this type of policy is the non-smoking policy in public places which had its origin in the form of a norm[3]. This bottom-up approach to the design of norms has not received a lot of attention, particularly, on the *detection* of norms which may be the precursors to policies[4]. Young [25] notes that *social norms exert a powerful influence on peoples behavior in many arenas, they are difficult to measure directly and are often neglected in the design of policy.* He identifies two issues with this statement, 1) the problem of measuring norms (i.e. uptake of the norm in a society which includes the problem of identifying a norm and its uptake in the society) and 2) the problem of norms being neglected in the context of policy design. In this work we aim to address (at least partially) these two issues.

Inferring or detecting norms[5] is a relatively new research area which involves the automatic identification of norms that exist in domains involving computer mediated human interactions (e.g. virtual environments such as second life [18] and massively multi-player online games). In these domains, it is possible to measure norms since huge volume of data is available through automatic logging of interactions between agents. Analysis of observed data in these digital environments can provide pointers to what the norms are. So, in this work we propose an approach to the design of policies that are based on inferring social practices of agents (i.e. norms) through extraction of commonly observed behaviour. These norms may originally exist only as personal norms (in the sense of Tuomela's p-norms [23]). They may not be known at the societal level. However, through observing the behaviour of individual agents from interaction logs, the aggregate/average behaviour of the society (a norm) can be identified[6]. Upon identification, social norms approach can be used to spread the norms. When the norm is successfully spread, it can be elevated to a policy.

Thus, the overarching goal of this paper is to discuss an approach where policies can be designed based on the strength of the norms. Towards this end, this paper proposes a hybrid architecture that combines both top-down and bottom-up approaches for the detection of norms and its elevation to a policy in an organizational and societal setting respectively. Norm identification is demonstrated using the data from a real world case study on the duplex printing

[3] We acknowledge that the non-smoking norm and the penalties for violation differ subtly from country to country [7]).

[4] We do not claim that norms are the basis for all types of policies. There is considerable evidence that quite a few policies have their origins in norms (e.g. non-smoking policy in public places). Several researchers have also investigated the role of international norms on domestic policy making (for an overview, see [6]).

[5] Several norm typologies exist (e.g. the work of Gibbs [9]). Conventions and norms are broadly treated under the umbrella of norms in this work.

[6] In this work identified aggregate behaviour is then spread as a norm to agents.

norm in an organization (Section 4). Norm spreading is demonstrated using a simulation-based study on energy conservation norm in a societal setting (Section 5). A discussion of future work is presented in Section 6 and the conclusions are provided in Section 7.

2 Background

Social norms are *generalized expectations of behaviour* in a society [11]. When a social norm is in-force in a given situation, members of a society expect other members of the society to behave in a certain way (e.g. exchanging gifts at Christmas and keeping the public space clean by not littering). Norms have been employed by human societies to facilitate cooperation and coordination among agents which enable smoother functioning of the society. Social norms are increasingly being employed in social norms approach (or social norms marketing) [20], where they are used to influence (or nudge) people into pursuing appropriate social behaviour. The main objective of the social norms approach is to alleviate the misunderstanding of norms[7]. Examples of such approaches include social norm based campaigns to reduce energy consumption in households, and increase recycling.

In this paper we refer to a class of norms called *green norms*. Green norms are norms that contribute towards achieving sustainability goals of a society. Sustainability is a overloaded term [14]. Here we refer to sustainability goals as those goals that aim at promoting activities which meet the needs of the present without compromising the ability of future generations to meet their own needs [4]. Examples of green norms in societies include reduction of electricity consumption, reduction of household and industrial wastes and the uptake of recycling. *Green norms thus aim to facilitate the greening of the world*[8] *by prescribing activities that are aligned with sustainability goals and proscribing activities that are detrimental to achieve sustainability goals (i.e. obligation and prohibition norms respectively).* In this work, two green norms are considered: 1) the duplex printing norm in an organizational setting (energy and paper conservation) and 2) the reduction of electricity consumption in the societal setting.

3 Hybrid architecture

This section provides a high-level overview of the architecture for an organization that can employ both bottom-up and top-down approaches for green norm

[7] For example, in the context of alcohol consumption among university students, there might be a misperception of the average amount of alcohol consumed by the agents, which can be alleviated through a social norms propaganda.

[8] The concept of greening is closely related to environmental sustainability which covers a broad umbrella of activities including the reduction of CO2 level, reducing chemical wastes and recycling.

detection, spreading and its elevation to a policy. A high-level architectural diagram is presented in Figure 1 which consists of four steps. A detailed diagram depicting the internal details of the four steps involved is given in Figure 2.

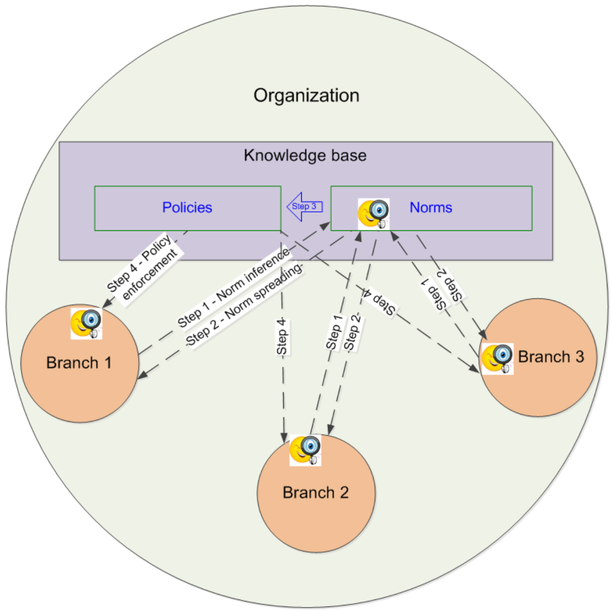

Fig. 1. Architecture for the elevation of norms to policies

Figure 1 is a box and line diagram that shows an organization that consists of three branches. The organization is represented as a large circle and the branches within the organization are represented as small circles. The knowledge of the organization is represented as a large rectangular box which includes its policies (rules) and other *know how* and operational details. Some norms (informal rules)[9] may also be known at the organization level. However, some emergent norms may not be known at the organizational level. We describe the four steps associated with the architecture below.

- **Step 1:** The first step involves the extraction (or the identification) of the organization-wide unknown normative behaviour (emergent behaviour). The process of norm identification is elaborated in Section 4 using an example. The example is the normative behaviour associated with duplex printing in an organizational setting. Without any explicit policy, a substantial proportion of agents may print in the duplex mode mainly because they may

[9] Rules are centrally enforced while norms have informal enforcements (i.e. for norm violations, sanctions are administered at peer to peer level rather than a centralized enforcer [17].

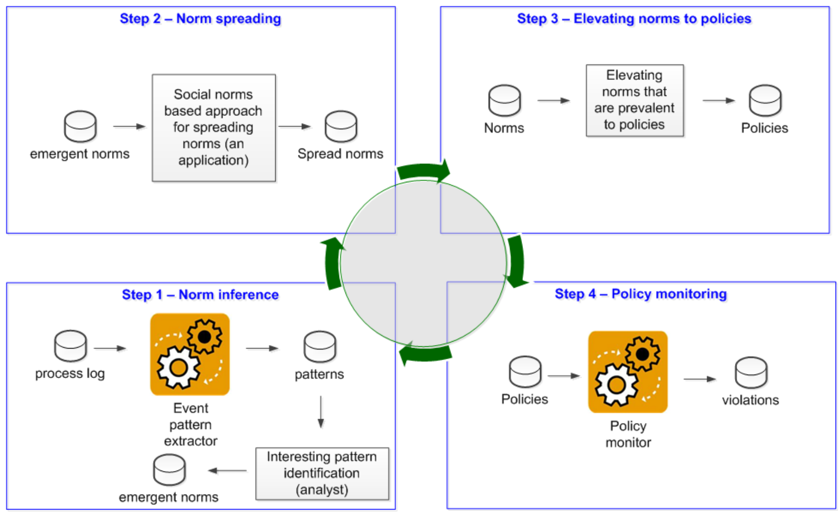

Fig. 2. Four steps of the architecture

have a personal norm to reduce paper waste. However, this behavioural regularity (i.e. a group norm) may not be known to all the agents (i.e. at the organizational level). So, this information can be extracted from the print logs available in an organization and the agents can be made aware of the emergent norm. In our architecture, an agent in a branch is responsible for extracting relevant norms from available data sources (or logs). There are three agents corresponding to three branches to extract norms (behavioural regularity in a particular context - duplex printing in this case). The agents communicate their findings to the norm aggregation agent (shown inside the norms box in Figure 1) which then informs the decision makers about the behavioural regularity or the lack there of.

– **Step 2:** It could be that the emergent norms may be prevalent in some branches but not in others. Then, those identified norms can be spread using a social norms approach [5]. This step is elaborated further in Section 5.
– **Step 3:** The norms that are spread through social norms approach may become prevalent in the organization. For example, 80% of the organization may follow a particular norm, hence, the organization may decide to elevate that norm to a policy.
– **Step 4:** Upon successful establishment of a norm as a policy, the agents in the branches monitor norm compliance. The agents report norm violations to the aggregation agent. Appropriate incentive or disincentive mechanisms should be set-up at the organizational level to sustain the established practice.

In the next two section we will discuss how norms can be identified and spread respectively using examples from two different domains (duplex printing norm and energy conservation norm respectively).

4 Emergent norm identification

This section describes how emergent norms may be identified in organizations. Let us consider the example where an organization logs printing behaviours of employees and would like to identify the norm associated with duplex printing. The organization may have recorded printing logs just for record keeping purposes (e.g. to archive who printed what documents). With the advent of sustainability norms (e.g ISO norms [1]) for organizations that call for reduced energy consumption through optimization of processes and the adoption of green practices, these logs can be used for purposes other than those that were originally intended (i.e. to identify norms).

The print log from a printer typically contains information such as the printer name, the user identification number, the document name, the number of pages printed, number of copies printed, the printer mode (duplex or non-duplex) and the time of print request.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Time	User	Pages	Copies	Printer	Document Name		Paper Size	Language	Height	Width	Duplex	Grayscale	Size
2	8/07/2011 16:21	user20	1	1	is10th-PCL-Duplex	HughODonnell.txt		A4	PCL6			DUPLEX	GRAYSCALE	43kb
3	8/07/2011 16:39	user41	7	1	is9th-upd-PCL-duplex	cms20111_submissic		A4	EMF			DUPLEX	NOT GRAYS	36902kb
4	8/07/2011 16:56	user44	2	1	is9th-upd-PCL-duplex	AAI.pdf		A4	EMF			DUPLEX	NOT GRAYS	3972kb
5	8/07/2011 17:48	user41	5	1	is9th-upd-PCL-duplex	SI.pdf		A4	EMF			DUPLEX	NOT GRAYS	3421kb
6	8/07/2011 19:13	user47	3	1	is9th	Microsoft Word - wo		A4	PCL6			NOT DUPL	GRAYSCALE	241kb
7	8/07/2011 19:14	user12	1	1	is9th-Duplex	TELE302CourseOutlir		A4	PCL6			DUPLEX	GRAYSCALE	396kb
8	8/07/2011 19:18	user42	2	1	is9th-Duplex	Microsoft Word - Thr		A4	PCL6			DUPLEX	GRAYSCALE	54kb
9	8/07/2011 19:24	user47	31	1	is9th-Duplex	AAI.pdf		A4	PCL6			DUPLEX	GRAYSCALE	6955kb
10	8/07/2011 20:19	user12	20	1	is9th-Duplex	ramanujan.pdf		A4	PCL6			DUPLEX	GRAYSCALE	22624kb
11	8/07/2011 20:21	user12	86	1	is9th-Duplex	ns.pdf		A4	PCL6			DUPLEX	GRAYSCALE	71121kb
12	9/07/2011 14:42	user12	1	1	is11th-colour-duplex	Microsoft PowerPoir		A4	PCL5	297mm	210mm	DUPLEX	NOT GRAYS	840kb
13	9/07/2011 14:44	user12	10	1	is9th-Duplex	ns.pdf		A4	EMF			DUPLEX	NOT GRAYS	98841kb

Fig. 3. A sample print log

Administrators in organizations can check for common usage patterns of the printers to answer question such as what are the prevalent printing modes of users (single or duplex), when can printers be safely turned off without causing any disruption and when does the user print large documents (and also can this be rescheduled to off-peak time to avail cheaper energy rates). For the purpose of this paper, we only consider the printing mode of the user.

4.1 Case study on norm identification

This case-study is on the usage of printers among the staff and post graduate students at the department of Information Science at the University of Otago. Print jobs successfully completed by seven printers over a period of 5 months (July to November 2011) were recorded in a print log. A snapshot of the print log is provided in Figure 3.

A collective behaviour (a norm) may exist due to a match in individual preferences. Individual members of the department may have a personal norm of reducing the amount of paper used in printing and may choose to print in the duplex mode. However, the prevalance of this green behaviour (or a green norm) may not be known at the organizational level (i.e. it may not be known as a group norm followed in the society). In this work, we investigated the uptake of the green norm in the department.

Table 1 provides the summary of the observations made from the print log. For each printer three characteristics were identified which are discussed below.

1. **Page count** captures a) total number of pages and b) the percentage of pages (given within parentheses in Table 1) printed both in duplex and non-duplex modes. Columns three and four show these two details for duplex and non-duplex modes. Columns three and four of row three shows that printer P1 printed a total of 21083 pages. 17042 pages were printed in the duplex mode and 4014 were printed in the non-duplex mode and these correspond to 80.83% and 19.17% printing done respectively in these two modes.
2. **Job count** captures a) the total number of jobs completed and b) the percentage of jobs (given within parantheses) printed both in duplex and non-duplex modes. A job submitted to a printer corresponds to printing one or more pages. Columns three and four of row four shows that printer P1 completed 2427 jobs. This amounted to printing 17042 pages. Columns three and four of row four show that there were a total of 3195 jobs in total. 2427 jobs were for printing in duplex mode and 768 were for printing in non-duplex mode which correspond to 75.96% and 24.04% of printing jobs completed by the printer in these two modes.
3. **Contribution** quantifies the contribution of a printer to the overall departmental printing (i.e. proportion of the total volume of printing done in the department in percentage). Columns five and six show the contribution of a printer (in duplex and non-duplex modes) to the overal printing volume. Printer P1 printed 62.38% of all pages printed in the department in the duplex mode and 38.89% of all non-duplex pages printed in the department.

It can be observed that printer `P1` is the most frequently-used printer. It accounts for 62.89% of all duplex-mode jobs completed by all the printers we considered in this study. Aggregating over all printers, 72.45% of the pages were printed in the duplex-mode (63.10% of the jobs). So, it can be said that there exists a norm of duplex printing in a society (assuming the threshold for norm emergence to be 60%)[10].

It can be argued that job count represents the intentions of users to print in the duplex mode. If that forms the basis of the norm (instead of the norm being based on total number of pages printed), it should be noted that only users of printers P1 and P3 have the duplex-printing norm (all the others are below 60%). Users of printers P4 and P5 do not undertake any duplex printing[11]. It

[10] A norm is said to have emerged if it is followed by a considerable proportion of society and this fact is recognized by most agents. Researchers have used values for norm emergence to vary from 35 to 100 [17].

[11] The exact reason for this is currently being investigated. It could be that the users are administrative staff who need to produce documents printed just on one side. In this work we recognize that printing in the duplex mode might not be possible at

		Number (Percentage)			
		Duplex	Non-Duplex	Contrib. (Dup.)	Contrib. (Non-Dup.)
P1	page count	17042 (80.83%)	4041 (19.17%)	62.38%	38.89%
	job count	2427 (75.96%)	768 (24.04%)	62.89%	34.03%
P2	page count	6322 (70.43%)	2654 (29.57%)	23.14%	25.54%
	job count	1057 (58.37%)	754 (41.63%)	27.39%	33.41%
P3	page count	3530 (75.22%)	1163 (24.78%)	12.92%	11.19%
	job count	336 (55.35%)	271 (44.65%)	8.71%	12.01%
P4	page count	0 (0.00%)	450 (100.00%)	0.00%	4.33%
	job count	0 (0.00%)	118 (100.00%)	0.00%	5.23%
P5	page count	0 (0.00%)	1053 (100.00%)	0.00%	10.13%
	job count	0 (0.00%)	112 (100.00%)	0.00%	4.96%
P6	page count	235 (81.88%)	52 (18.12%)	0.86%	0.50%
	job count	9 (23.68%)	29 (76.32%)	0.23%	1.28%
P7	page count	4 (1.04%)	382 (98.96%)	0.01%	3.68%
	job count	1 (1.79%)	55 (98.21%)	0.03%	2.44%
Total	page count	27320 (72.45%)	10390 (27.55%)	–	–
	job count	3859 (63.10%)	2257 (36.9%)	–	–

Table 1. Statistics regarding duplex vs. non-duplex printings on a total of 7 printers over a period of 5 months at the department of Information Science.

is interesting to note that in printer P6, the percentages for page count and job count vary significantly (81.88% vs. 23.68%). Printers P6 and P7 also do not have a duplex printing norm. Once the norm is identified, it can be spread to the users of printers that do not have the norm using a social norms approach (discussed in next section).

5 Norm spreading using social norms approach

Researchers have found that social norm based messages help in bringing about positive changes in domains such as littering in public places, alcohol consumption, resource stealing (petrified wood stealing in Arizona national park), reuse (e.g. reusing hotel towels) and energy conservation (cf. [19]). In particular, these works note that both descriptive and injunctive norms should be used in conjunction for facilitating a positive behavioural change. According to Kitts and Chiang [15] the definitions of descriptive and injunctive norms are as follows. *Descriptive norms are typical patterns of behavior, generally accompanied by the expectation that people will behave according to the pattern. Injunctive norms are prescriptive (or proscriptive) rules specifying behavior that persons ought (or ought not) to engage in.* It should be noted that descriptive norm on their own do not encourage positive behaviour to a large extent and in some cases boomerang effects were observed [20] resulting in mixed benefits in the usage of social norms.

all times for all users (e.g. staff may have to submit formal applications printed in only on one side). However, the aim is to encourage duplex printing norm whenever possible.

For example, when the messages based on descriptive norm informing users that they consume low energy than their neighbours was sent, *boomerang effect* was observed where the users started consuming higher amount of energy [20] than their previous consumption. The boomerang effect was eliminated when the injunctive norms were added.

Schultz et al. [20] examined the influence of descriptive and injunctive norms on overall reduction in energy consumption in households using a social norm based approach. The messages constructed using social norms approach were based on the average energy consumed in the neighbourhood of 290 houses. The energy consumption of all the houses in the neighbourhood is used to compute the minimum, maximum and average energy in the neighbourhood and these values are used to construct the normative messages. The descriptive norm based messages that were sent to the participants contained information about the household's energy usage and whether its energy consumption was below or above the average energy consumption of the neighbourhood. As a result of receiving normative messages, it was observed that households that consumed energy higher than the average tended to decrease their energy consumption. On the other hand, households that consumed less energy than the average increased their energy consumption (i.e. the boomerang effect). A limitation of this study is the small sample size chosen for investigation. Additionally, various 'what-if' scenario analysis based on varying the percentage of agents influenced by boomerang effect could not be performed since it was a real-life study. The work of Savarimuthu et al. [19] on the other hand using a simulation-based study have shown how the boomerang influence can be eliminated when both descriptive and injunctive norm-based information is included in normative messages. The work also investigated norm spread on three types of topologies and their impact on convergence times to a norm and also the extent of reduction in energy consumption is facilitated in the three types of networks. However, the work does not demonstrate the impact of boomerang influence in the simulation context. Demonstrating how norms can be spread using a social norms approach and also investigating the impact of boomerang effect on norm spreading using a simulation study forms the focus of Section 5.2. In the next sub-section 5.1 we discuss different approaches to norm spreading.

5.1 Approaches to norm spreading

In the duplex printing case study, the uptake (or the salience) of the norm differed across the users of different printers. A social norms based application can be designed to spread these emergent norms across different branches. Norms in societies can be spread through different ways. Traditional approaches used in social norms marketing include broadcasting advertisements in common knowledge sources such as national televisions, radios, newspapers and the distribution of pamphlets. Some approaches for spreading norms in the context of duplex printing in an organizational setting are given below.

- Email messages - Organizations can promote emergent norms to be adopted through email messages. For example, organizations can send periodic mes-

sages to decrease the amount of energy consumed (e.g. providing advice such as switching off appliances when leaving office), reporting the aggregate behaviour and encouraging users to achieve a overall target set by the organizations.
– Social networks - Organizations can promote emergent norms through social network applications. For example, energy consumption of users can be linked to social networks, where reduction in energy by a member can influence energy reduction behaviour in the member's friendship circles. Applications that aim at nudging people to reduce their energy consumption are in development. Facebook has recently announced that such an application based on OPOWER's initiative to use social norms based messages to nudge people to reduce energy consumption [2].

Other strategies that can be used for faster norm establishments include creating competitive environments (e.g. recognition for the branch with larger printing norm uptake), facilitating incentive mechanisms for duplex printing and disincentives for those who use single page printing predominantly). Incentives could be social incentives (e.g. being recognized as a green member) or financial incentive (e.g. free coffee).

5.2 Simulation-based study of spreading the energy conservation norm

In order to demonstrate how identified norms can spread in a society, we simulated a society of agents. The objectives of the simulation are two fold. First, we demonstrate that spreading norms leads to reduction in energy consumed in a society. Second, we describe our investigations on the impact of boomerang effect in energy reduction in an agent society.

In our simulations, agents represent individual houses. Each agent has certain parameters. The parameters are a) a unique identifier of the house, b) the number of people living in the house and c) the energy consumed per month in Kilowatt hour (KWh) by the household. We used the data available from the Government of South Australia[12] for initializing the average energy consumption of agents. We modelled households with members ranging from one to five. The average energy consumed by the households per month is given in Table 2.

In this work, agents were randomly initialized with the number of people living in a household. Since our model considers households with sizes ranging from one to five, 20% of agents have the same value for the number of members in the household. The energy consumed by a household was initialized with a value that lies within plus or minus x% of the average energy consumed by household. For example, if x is set to 25, an agent representing a household with five members will be initialized with a value that lies between 891 and 1485.

After initialization, we assume that normative messages are sent to each agent (either electronically or by post) which informs the agents about the average

[12] http://tinyurl.com/3fhssbf

Table 2. Average energy consumption in households based on number of occupants (data from the Government of South Australia)

Number of people in the house	Average energy consumed per month (KWh)
1	479
2	642
3	738
4	829
5	1188

energy consumption of the entire society and whether their energy consumption is above or below the average. Note that the message is the descriptive norm that is being conveyed to the agents and the norm was originally identified through observing the aggregate behaviour of the agents (i.e. the norm is the average energy consumed by the agents in the society which was inferred from the data collected from the agents). In this model we assume that $y\%$ of agents that consume more energy than average choose to decrease their energy by $z\%$. For example if y=5 and z=5, that implies that 5% of the agents that consume more than average energy reduce their energy consumption by 5%. We also have set a buffer range, $\pm\alpha$ (around the current average energy consumed in the society which governs the limit upon reaching which the agents do not have to reduce their energy any further. This buffer range has been set in order to prevent agents from perpetually decreasing their energy until they reach a value of zero and doing so will not be realistic.

In order to understand these variables better let us consider the following example. Assume that agent A has five members and its current energy consumption for the month is 1680 KWh. Assume that the agent wants to reduce its energy consumption since its consumption is higher than the 1180 KWh which is the average energy consumption as informed to the agent through the normative message. So, the agent decreases its consumption value to 1410.75 KWh (assuming z=5). Assuming the buffer value of α=5, in further iterations if the agent decides to decrease it energy usage, it can do so to a minimum of 1247.4 assuming that average energy consumption in the society does not change in the subsequent iterations. The buffer range in this case is from 1128.6 to 1247.4. Note that the buffer is a sliding buffer and the minimum and maximum values depend upon the current energy consumption average of the entire population.

Each iteration of the simulation corresponds to one month in real-time. After each iteration we record the overall energy consumed in the society. This data is used to plot the average energy consumed by the society in KWh over several months. In this work we employ the similarity model where agents' norm-based messages report the average energy consumed by the agents that are similar to them[13]. In our model the similarity is based on the number of members in the household. Since there are five groups, average consumption energy is

[13] Applications that provide comparison of energy usages across households have started to appear in the marketplace (e.g. http://www.energyaverage.co.uk/).

calculated for all these five groups. Agents are informed about the average energy corresponding to the groups they are in. The buffer values of agents across the five groups will be different (i.e. there will be five different buffer values, one for each group).

In this work we simulated an agent society with 1000 agents. The parameters that were used in the three models are given in Table 3. The simulation has a fixed percentage of randomly chosen agents are influenced by norms in each iteration. For example, if the percentage is set to five, then the 50 agents in the society that are under the influence of norm in one iteration will be different from the agents under influence in the next iteration. This represents a society where agents that are influenced by norms are dynamic.

Table 3. Simulation parameters

Parameters	Values
Number of agents	1000
Range of initialization values (x)	± 25%
Percentage of agents influenced by norms[14] (y)	5%
Nature of agents influenced by norms	Dynamic
Percentage energy decrement (z)	5%
Buffer range around average (α)	± 5%
Number of iterations	1000
Number of runs	1000

We modeled the amount of boomerang influence (BI) in a society using a parameter. Boomerang influence (BI) represents the percentage of agents consuming energy less than average that increase their consumption due to boomerang effect. We compared the influences of certain percentage of agents that had boomerang tendencies (BI = 1%, 2%, 5%, 10%, 20%). For example, a BI value of 2% indicates that two percent of those agents that have consumed less than average energy have the tendency to increase the energy.

Two main observations can be made from Figure 4. First, it can be observed that without boomerang influence (represented by black solid line), the exchange of normative messages help in the reduction in the energy consumption in households (776 KWh in the start of the simulation vs. 682 KWh at the end of the simulation). Second, it is interesting to note that even a small percentage of agents can impact the amount of energy reduction in an agent society significantly when compared to the baseline experiment with no boomerang influence (see the circled region on the right hand side of the graph). Consider the line corresponding to 1% of agents that are under boomerang influence (i.e. they increase their energy since they are below the average energy consumed by the society). In this simulation, 5% of agents who are above the energy consumption average still decrease their energy while only 1% of agents increase their energy. We note that it may appear that the overall decrease in this case should be the same as if we had only 4% of agents that decrease their energy. However, that is not the case as shown in Figure 5[15]. When there are agents that are decreasing their energy consumption levels (i.e. agents with high consumption), the average energy consumed by the society starts to decrease from the higher end of the spectrum (i.e. agents with high energy start to lower the values). However, with the boomerang influence, agents start reducing the values from both spectrums, i.e., some agents with high energy lower their values and some agents with lower values start to increase their value. This results in the faster decrease of the average energy consumption values of agents which results in the faster convergence[16]. However, this impacts the amount of decrease in energy consumption. Even though the convergence is faster, it results in increase in the average energy consumed by the society, i.e., the average energy consumptions at the end of the simulations with boomerang influence are lower than the energy consumption average without boomerang influence (682 KWh vs. 725 KWh in Figure 5).

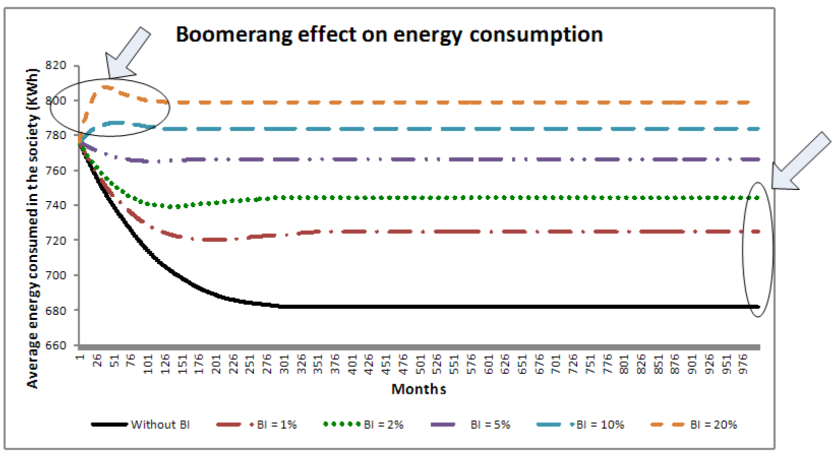

Fig. 4. Impact of boomerang effect

Additionally, it can be observed from Figure 4 that even for higher percentage of agents exhibiting boomerang influence (e.g. 10% and 20% respectively), the effect is not highly pronounced, i.e., energy consumption does not increase to a high value when compared to the initial values. This is because of the faster movement towards an average as a result of movement from both ends of the spectrum which prevents the energy consumption value from increasing to a very high value. The quick ascent of average energy values followed by the quick descent towards convergence can be seen in the region marked using an ellipse in the left side of Figure 4.

15 It should be noted that the energy reduction obtained without boomerang effect is higher (i.e. convergence to a lower consumption value) than with boomerang effect.

16 Note that the convergence to a value is faster for the lines at the top of Figure 4 (those with high BI values) than the lines at the bottom (low BI values).

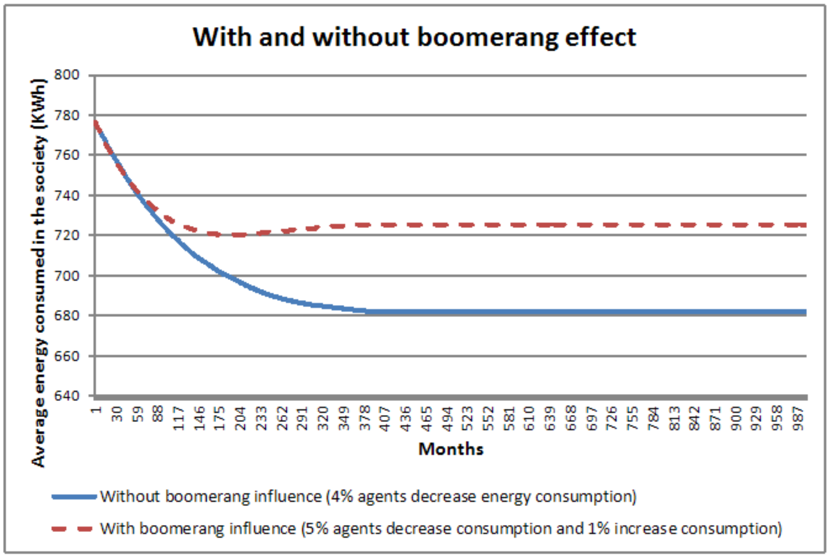

Fig. 5. Comparing two scenarios - with and without boomerang influences

6 Discussion

Some works on policy design for institutions have investigated the role of bottom-up (emergent or endogenous) [21] and top-down (prescriptive or exogenous) [22] approaches that facilitate behaviour modification in agent societies. They have shown that the results of policies that arise from an endogenous approach are different from those obtained from the exogenous approach. However, they do not propose how these two approaches can be combined or leveraged to design policies. In this paper we have discussed a hybrid architecture that combines both these approaches in the context of designing a policy from a norm. We believe the architecture can be used as a guiding template and can be applied for policy modeling in several domains. For example, emergent norms can be identified from game-logs in multi-player online games which can then be spread or at least made available through forums for new players to know. Conventions and norms that emerge dynamically during open source software development processes can be identified from large software repositories, can then be spread and made as a policy. Additionally, emergent norms in social networking sites such as Twitter (see work in [16]) can be identified, spread and be elevated to a policy.

We note that the work reported in this paper provides evidence for the first two steps of the architecture discussed in this paper (i.e. norm identification and norm spreading). We believe these two are relatively novel aspects of the system. Prior works exist that deal with steps 3 and 4 of the architecture discussed in this paper. The work of Savarimuthu et al. [19] provides pointers on when and how norms can be elevated to a policy (step 3 of the architecture) using a meta-norm based approach. Several researchers in normative multi-agent systems have investigated on norm compliance (e.g. [10]) and associated punitive measures (step 4 of the architecture). The next step is to choose appropriate implementations for steps 3 and 4 of our architecture and integrate them into our simulation system in the first instance. We also intend to create a social network based set-up in order to study the influence of social networks on normative behaviour (for both the study of duplex printing norm and the energy conservation norm) in real-life.

7 Conclusion

The contributions of this paper are three-fold. First, it discussed an architecture for the identification of norms using a bottom-up approach and its eventual adoption as a policy (top-down approach) once it has spread and has been adopted by significant proportion of agents in the society. Second, the identification of duplex printing norm was demonstrated using data from an organization. Third, norm spreading was demonstrated using a simulation-based study of the energy conservation norm in a society. Additionally, the impact of boomerang effect on norm spreading was also demonstrated.

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