He Endorses Me – He Endorses Me Not – He Endorses Me … Contextualized Reasoning in Complex Systems

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Abstract

Interaction between agents representing real world actors in computational models must be informed by knowledge about interaction processes occurring amongst real world actors. We propose the use of endorsements to implement the cognitive processes underlying the decisions that lead to interactions among agents. The main advantage in applying the idea of endorsements lies in the fact that they allow for combining the efficiency properties of numerical measures with the richness and subtleties of non-numerical measures of interest or belief. We demonstrate the expediency of our approach with two evidence-driven agent-based models. From these case studies we derive suggestions for suitable extensions of the endorsement concept.

Introduction

Interaction amongst agents representing real world actors in computational models must be informed by knowledge about interaction processes occurring amongst real world actors. The notion of endorsements, as applied by Moss (2000), helps to implement the cognitive processes that underlie the decisions leading to agent interaction processes. Endorsements capture a subjective, but socially embedded agent's reasoning process about cognitive trajectories aimed at achieving information and preferential clarity over another ("endorsed") agent. We apply endorsements in conjunction with declarative modeling. Whereas declarative modeling enables the implementation of evidence-based data into a model, endorsements provide a concept to capture the way agents reason about this evidence-based data. The implementation of software agents as adequate representations of real world actors is enhanced by designing agents to perceive events specified by qualitative descriptions, maintain the qualitative terms during processing these qualitative perceptions and then act in ways that can be characterized qualitatively. Thus, the advantage in applying the idea of endorsements lies in the fact that they allow for combining the efficiency properties of numerical measures with the richness and subtleties of non-numerical measures of interest or belief. The virtues of endorsements are exemplified by introducing two declarative social simulation models of conflict in Afghanistan and outsourcing dynamics in the banking industry respectively. Both models are evidence-based as they derive their agent rules directly from case-study-based insight into the target system. We enhance the notion of endorsements by demonstrating its usefulness for conceptualizing the cognitive dimensional framework agents apply to reason about other agents and propose an improved procedure for continuous data formalization for the endorsement process. Although we critically concede that endorsements as representation of real world actor cognition have limitations, we articulate their efficiency in the analysis of emergent socialites in a variety of socio-economic contexts.

What are endorsements?

Interactions between at least two actors play a pivotal role in most agent-based models. The computational implementation of these interactions must be based on certain grounds. This can be knowledge an actor has about another actor; it can also be experiences an actor has made in the past within his environment. Endorsements are a "natural" way of computationally implementing reasoning about this knowledge or experience.

Endorsements were introduced by Cohen (1985) as a device for resolving conflicts in rule-based expert systems (cf. also Moss 1998). Endorsements can be used to describe cognitive trajectories aimed at achieving information and preferential clarity over an agent or object from the perspective of the endorsing agent himself. We use endorsements exactly in this sense, namely to capture a process of reasoning about preferences and the establishment of a preferential ordering (cf. Moss 2000; Moss and Edmonds 2005).

Because endorsements capture the reasoning process of one agent, the *endorser*, about another agent, the *endorsee*,

the information collected by the endorser is not objective but of a subjective nature. During the endorsement process the endorser's endorsement scheme is projected onto the endorsee. In the case of the Afghan model (see below), if a commander endorses a businessman, he has no base to rate if the businessman would be a better Muslim if he is Sunni or Shia. But the individual endorsement scheme tells the commander how important it is for him that the businessman is Sunni or Shia. If this is done for each of the endorsee's attributes, the so called overall endorsement value E_{stat} for the endorsee can be calculated as depicted in equation (1)

$$E_{stat} = \sum_{e_i \geq 0} b^{e_i} - \sum_{e_i < 0} b^{|e_i|} \quad (1)$$

while b is the number base and e_i is the value of the i^{th} endorsement token. E_{stat} allows the endorser to choose the preferred one among a number of endorsees.

The process of choosing an agent is embedded in an agent's context, i.e. the agents visible or known to him. Relying on endorsements allows an agent to find the agent most appropriate to him within his context. This implies that the chosen agent may not be preferable to differently embedded agents with a different endorsement scheme.

Figure 1 depicts two agents, A_1 and A_2, in the process of endorsing a third agent, A_3. A_1 and A_2 have different contexts and different preferences which have an influence on their decision to choose an agent to endorse.

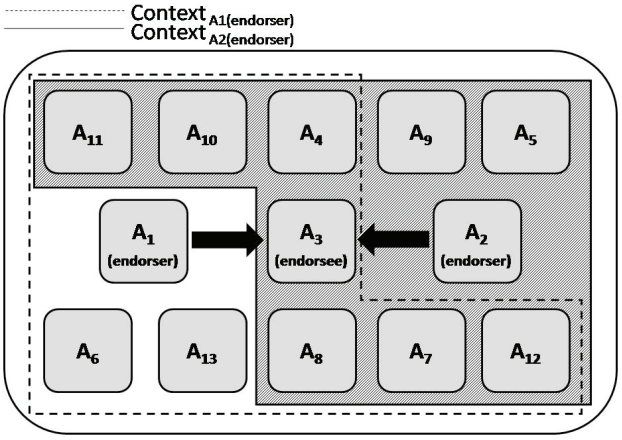

Figure 1. Schematic representation of the embeddedness of the endorsement process.

The main advantage in applying the idea of endorsements lies in the fact that they allow for combining the efficiency properties of numerical measures with the richness and subtleties of non-numerical measures of interest or belief.

When and how are endorsements applied?

Evidence-based modeling

Evidence denotes information about the target system that allows developing a representative model of reality. This information stems from case studies, empirically tested theories and interviews with experts and stakeholders. The triangulation of the information sources is vital for the model's validity. A model is evidence-based if the rules according to which agents behave are directly derived and reified from this information. This presupposes that the data makes concrete declarations of how an actor behaves in a particular social situation.

Unlike other simulation approaches, evidence-based modeling pursues construct validity. It is important that the modeled processes and structures resemble the processes and structures identified in the target system (cf. Boero and Squazzoni 2005). Agent-based models are more than mere input–output models. As demanded by critical realism, they direct a researcher's focus on internal processes (agency) and structures and allow for the analysis of them.

Results are more valid if an evidence-based social simulation's output can be cross-validated (cf. Moss and Edmonds 2005) and not only "validated" by circumstantial evidence. There are three strategies: i) if models generate numerical output, this output is statistically analyzed and the resulting significant signatures are compared with statistical signatures generated from target system data. If no statistical target system data is available, then validation must rely on qualitative data. In this case, validation must ii) either seek systematic structural and processual similarities between the model and the target system or iii) find circumstantial evidence in the target system that can also be found in the simulation.

Declarative modeling

A program is declarative if it applies facts and rules to model the target system's behavior. Facts describe the system's state or, if used in agent-based simulations, the agents' knowledge about the system. Rules are used to produce new facts and delete or alter existing facts, or in other words, to manipulate the agents' knowledge. Each rule consists of a set of conditions and a set of actions to be performed when there are facts that match the conditions. The sequence of rules that will fire, and the particular facts that will match them, are determined only as the program is running. The sequence of actions represents the process of agent behavior and leads in each case to a new state of the environment. If all agents are implemented declaratively, then they will be changing the state of the environment for one another and the pattern of rules and therefore actions of all of the agents taken together will be influenced by one another.

The outcomes for the model as a whole are, in these circumstances, impossible to predict with any exactitude.

Frequently, such models exhibit the sort of episodic volatility associated with complexity. The same effect can be achieved by other means, but declarative representations of agents have a number of virtues in terms of ease of development as new evidence becomes available and in terms of yielding comprehensible outputs.

In the case of the models presented in this paper the Java Expert System Shell (JESS) was chosen as an appropriate tool for incorporation of the declarative approach into the modeling process.[1]

Applications of endorsements

Modeling IT-Outsourcing with Endorsements

The first model (TCTModel) we present is concerned with Information Technology / Services (IT/S) outsourcing relationships between clients in big financial institutions, i.e. banks, and vendors in the corresponding narrow market. The aim is to better understand the influence of the social setting that banks are located in, on the outcomes of the outsourcing contracts. The current version of the model presented is based on the framework of Transaction Cost Theory (see below) enriched by the qualitative data extracted from a case study.

The strategic importance of IT/S in the banking sector is commonly accepted (BCG 2006; OECD 1992), yet banks still continue to outsource parts of their information services and some even outsource them entirely (Ang and Detmar 2002). A recent report in the annual series of BCG benchmarking publications stipulates that only relatively few European banks have benefited from IT/S outsourcing to the extent they anticipated. Nonetheless, most intended to increase outsourcing activities in pursuit of reduced labor costs, specialized skills, process expertise, superior technical resources, and increased ability to focus on core business (BCG 2005).

At first glance, this trend appears counterintuitive. In compliance with the classical theory of the firm, organizations ought to have a constant aspiration to autonomy, thus trying to take as many essential business activities under their wing as possible in order to maintain relative independence (Gouldner 1959). On the other hand, the economic downturn of late 2000 reinforced re-engineering issues within many of the corporations in order to survive in the face of volatile competition.

Past research on IT/S outsourcing has mainly focused on the transaction itself, without investigating the strategic characteristics of the organization (Aubert and Croteau 2005), not to mention a built-in social framework of the firm or the social context it is located in. This trend captures the widely held perception that organizational members make sourcing decisions based upon an economic rationale and regard social factors as negligible in their influence on the overall picture of outsourcing. Therefore, a representative strand of research on IT/S sourcing has used the Transaction Cost Theory (TCT) (Williamson 1975) to investigate make-or-buy decisions.

The TCTModel introduces a novel approach for investigation of the TCT. It applies agent-based social simulation and tries to model actors of the outsourcing process as autonomous and heterogeneous agents that react to changes in the environment they are located in. Social structures emerge from the interaction and information exchange between individuals in the market. This approach is contrary to standard economic literature with its assumption of homogeneous actors.

The evidence, which informs the TCTModel, stems from semi-structured interviews conducted with stakeholders and domain experts in the industry.

As already mentioned above, the TCTModel tries to escape the conventional stereotypes of economic models with their assumption of homogeneity in the modeled system. Thus the model consists of two types of potentially interconnected agents: clients and vendors.

Following the implied economic pressure, agents are impelled to interact with each other in order to survive in the volatile competition. The set of rules used to describe each agent type's reasoning behavior is inspired both, by Williamson's TCT framework and by evidence from interviews. In order for the rules to fire, the environment has to exhibit certain stimuli and conditions *a priori*. The endorsement scheme of a particular agent gives this agent the cognitive ability to reason about these stimuli and conditions.

The behavioral logic of the TCTModel can be summarized as follows: A client is assumed to have a constant drive for subcontracting a third-party vendor for transferring some previously in-house services to this vendor. Subcontracting a vendor might not always be a better solution but this assumption was necessary for keeping a constant impulse to interact. Depending on the evaluation of the vendors' portfolios (several service characteristics the vendor is offering, price for the service, performance of the service etc.) a client will either send a contractual offer or not.

A vendor, in turn, will perform an evaluation of all the offers received based on several vendor-specific preferences with regard to clients. Only the most appropriate client will receive a granted offer, whereas other applicants will be rejected. During a transaction each of the two partners may opt out of the contract prematurely or stay committed until the natural end of the transaction. In the case of a premature end of the transaction, sanctions are imposed on the defecting partner.

Based on the conducted interviews and secondary data from literature and media, an endorsement scheme for each agent type was developed. Several questions played a pivotal role in this process: Which properties shall a transaction partner possess *ex ante*? How shall the behavior of the corresponding party be monitored? When is the threshold reached to opt out of the transaction prematurely?

[1] For further information see http://herzberg.ca.sandia.gov/jess/

The analysis of the data available was done under the aspect of these questions.

According to TCT, the specificity of an investment (an asset) determines the risk in the transaction relationship. In the dyad of exchange parties this risk can be considered as perceived risk. However, the interview partners mentioned several other important influences on perceived risk: trust, reliability, reputation, personal relationship and size of the contracting partner. Whereas the distinctiveness of some of these terms might be arguable, they were clearly important to all interviewees and so were adopted for the model.

The personal relationship was classified as an indirect attribute contributing to the overall contractual picture, or as one of the interviewees put it: "[…] having a good contract doesn't insure us a good personal relationship with the vendor but by starting with a good personal relationship we can reap good contracts". Reputation, trustworthiness and reliability ought to play a pivotal role in the perceived risk and thus in the resulting estimates of the expected transaction costs. The later three factors were linked to the risk through the individual propensity of the transaction partner to act in an opportunistic way.

Trust, reliability and loyalty are operationalized computationally by means of endorsements (see table 1). Endorsements are used to capture the agents' process of reasoning about preferences and the consecutive establishment of preferential ordering.

Static	Dynamic
big-size/small-size,	reliable/unreliable,
discount-policy/no-discount-policy	good-personal-relationship/bad-personal relationship,
	trustworthy/untrustworthy, good-reputation/bad-reputation

Table 1. A client/vendor agent's endorsement scheme.

Whereas the size and the contractual policy are anchored as static properties, which are not changing throughout the simulation, tags like reliability, trustworthiness and reputation are subject to a particular agent's experiences, thus might change dynamically.

Each agent in TCTModel is assigned its (numerically) individual endorsement scheme by giving each of the endorsements listed in table 1 a different weight for each agent. This means that while one agent cares most about reliability, another agent might consider size and good reputation as more crucial factors. Therefore, endorsers base their decision on whether to interact with the endorsee upon the existence and weights of particular endorsements. If there are several endorsees, which fit the desired profile, the endorsee with the highest preference match – i.e. the highest E_{stat} – is chosen.

As a preliminary conclusion, endorsements in general provided a means for incorporating temporal and social aspects into the purely economic TCT. The model representing a pure theory *in statu nascendi*, would not lend any insight into actors' reasoning process, whereas the use of endorsements helped to implement a reasoning process, which is close to the evidence provided by the interviewed stakeholders. Overall, one can stipulate that the results and dynamics seen in the model are as a direct result of the implemented endorsement schemes.

Modeling Power Structures in Afghanistan with Endorsements

The second application we are presenting is about modeling power structures in Afghanistan.. The aim is to better understand the dynamic complexities of Afghan power politics with regard to the emergence of actor networks, alliance building (cooperation) and conflict.

The *qawm* is a dominating feature of Afghan society (Roy 1995). Mousavi (1997) refers to it as a complex interpersonal network of political, social, economic, military, and cultural relations. Afghan social structure does not take the form of a unified hierarchy and nor does an individual *qawm*. However, each *qawm* has a *primus inter pares* who competes with other *primi inter pares* as well as with *qawm*-internal rivals for manifold reasons (Roy 1994). The *qawm* is therefore a useful concept for the development of a dynamic and structural-functional representation of Afghan power structures

A number of case studies suggest that behavior in contemporary conflict must be understood as neo-patrimonial (Bayart, Ellis and Hibou 1999; Reno 1998). Neo-patrimonialism is a stakeholder's ability to accumulate and redistribute material and social resources for the sake of gaining or maintaining power (cf. Geller 2006). This necessitates that the neo-patrimonial strongmen are socially well-embedded. In general, this holds true for Afghanistan as well (cf. Azoy 2003; Tarzi 1993), but needs to be materialized for the model development.

The evidence by which the *qawm*-model is informed is founded on qualitative data stemming from casestudies (cf. Azoy 2003; Mousavi 1997; Roy 1995, 1994, 1990; Schetter 2005; Tarzi 1993) and data collected by ourselves during semi-structured interviews with Afghan urban elites between May 2006 and January 2007. The main reason why the model has to rely on rich qualitative data is the lack of reliable statistical data in Afghanistan and other comparable contexts. (The main reasons it depends on evidence-based information have been explained above.)

The *qawm*-model consists of ten types of potentially interconnected agents: Politicians, commanders, religious leaders, businessmen, organized criminals, drug farmers, drug dealers, farmers, warriors and civilians. Following the logic of neo-patrimonialism behavior agents are impelled to interact with each other if they want to succeed. The set of rules according to which the agents behave are derived from the qualitative evidence we have. The agent behavior, of course, must have cognitive foundations and the execution of a particular action, i.e. a rule, must be triggered by a defined stimulus and confined by certain

conditions. The endorsement scheme dimensionally represents an agent's cognition with respect to these stimuli and conditions.

The behavioral logic of the *qawm*-model is as follows: If a politician is in need of military protection, he approaches a commander. In return, a commander receives political appreciation by mere cooperation with a politician. If a businessman wants to be awarded an official construction contract by the government, he relies on a politician's political connections. In return, the politician receives a monetary provision, for example, bribes. If a politician wants beneficial publicity, he asks a religious leader for support. The religious leader, in return, becomes perceived as a religious authority. If a warrior seeks protection and subsistence for his family, he lends his services to a commander, who, in return, provides him with weapons, clothes, food and/or money. If an organized criminal wants to carry drugs, he relies on the transport business of a businessman who, in return, receives a share of the drugs sold. If a drug farmer needs protection for his poppy fields, he affiliates with a commander, who, in return, receives a tithe on the drugs sold to a local drug dealer.

Based on the available interview and secondary data, particularly Azoy (2003), an endorsement scheme for an ideal typical "Afghan agent" was developed. In principle it had to correspond to the following questions: When is an agent powerful? How does a powerful agent behave? How does another agent behave towards a powerful agent? Azoy (2003) argues that authority depends on *hisiyat*, character, and *e'tibar*, credit. The analysis of our interview data supports this view. Consequentially, *hisiyat* and *e'tibar* are the dimensions an "Afghan agent" reasons about another agent. *Hisiyat* is related to the social embeddedness of an actor. An actor has character if he is of particular kin, religion, neighborhood and/or politico-historical background and can, in the case of cultural pattern matching, be trusted. An actor who is creditworthy and has political support possesses *e'tibar*. *E'tibar* has to do with meritocracy and reliability.

Hisiyat and *e'tibar* can be straightforwardly operationalized (see table 2). *Hisiyat* are intangible endorsements and are attributed at the beginning of the simulation, such as ethnicity, religion or kin. *E'tibar* are dynamic endorsements which change their values during the simulation, such as payment or success.

Afghan Agent	Static	Dynamic
Hisiyat	pious/sinful	loyal/disloyal
	intellectual/non-scholarly	politico-military background
	shared-ethnicity/different-ethnicity	generous/stingy
	shared-religion/different-religion	
	is-kin/non-kin	
E'tibar		reliable/unreliable
		is-neighbor/non-neighbor
		successful/unsuccessful
		capable/incapable
		recommended/condemn

Table 2. An Afghan agent's endorsement scheme.

Statistical data is scarce in Afghanistan (and if available highly politicized and therefore unreliable). Reliable qualitative data, *per contra*, is obtainable. Moreover, qualitative data lends insight into actors' reasoning processes and is therefore of direct use in the agent modeling process. The notions of *hisiyat* and *e'tibar* do not need to be operationalized anymore but can be directly translated into a declarative programming language describing the agents' behavior.

In the Afghan model each agent is attributed his numerically individual endorsement scheme. This means that each agent rates during the endorsement process each endorsement individually. While for one endorser it is more important that the endorsee is pious, for another agent it is more important that he is of the same kin as the endorser himself. Or while it is more important for one endorser that an endorsee is reliable, another endorser considers it of greater importance that an endorsee is successful.

Endorsers base their decision on whether to interact with an endorsee on the existence of a particular endorsement. If, for example, a commander wants to ameliorate his reputation by being perceived as pious, he endorses a religious leader. The religious leader must comply with the commander's expectations, i.e. must, for example, be of the right kin, religion and ethnicity. Once positively endorsed by the commander, it is up to the religious leader to endorse the commander. For the religious leader, for example, it is important that the commander is from a particular politico-military background and that he is successful. If these two conditions are matched, then both agents affiliate with each other. If there is more than one endorsee, then the endorsee is chosen whose overall endorsement value matches the endorser's expectations best, i.e. has the highest E_{stat}.

In summary, endorsements in the Afghan model do not only provide a means to overcome statistical data scarcity, but in fact help to implement an evidence-based reasoning scheme and therefore make a virtue of necessity. Finally, endorsements form the decisions on which the agents base their behavior. The model's dynamics and structural outcome are a direct result of the implemented endorsement scheme.

Implications for Future Research

Heterogeneity of Endorsement Schemes

In both models presented here, all agents dispose over structurally equal endorsement schemes. (Of course each individual agent's endorsement scheme exhibits individual values for b, the number base, and e_i, the value of the i^{th}

endorsement token.) The implementation of homogeneous endorsement schemes led to acceptable simulation results, despite being a gross simplification and also a step backwards in terms of modeling methodology.

Homogeneous endorsement schemes tilt towards the same weakness as statistical models by neglecting the heterogeneity of social reality. Different agent types have different functional characteristics and should therefore also have a cognitive structure that corresponds with their agent type.

For example in the case of the TCT model, the endorsement scheme consisting of trust, reliability, reputation, personal relationship should have a diverse range of weightings on certain endorsements. In particular, according to the interviewees, the factors which influence the perception of risk for the client are different to those for the vendor. Clients consider trust, reliability and personal relationship as crucial building blocks of a healthy transaction whereas vendors, on the other hand, do care more about the client's reputation.

In the case of the Afghan model the issue remains the same. A drug farmer, for example, cares less about ethnicity when interacting with a drug dealer than a politician but more about regular payments in full. A politician, on the other hand, ought to care more about ethnicity as interaction when the wrong ethnicities might harm his reputation.

The solution for this problem is to assign an agent not completely randomized endorsement weights e_i, but weights which are in accordance with the agent type. Hence, if we assume that the drug farmer is most sensitive to not being paid in full and not being paid on time, the *reliable* endorsement must be considered more important and therefore receive a higher weight than any other endorsement in this particular agent's endorsement scheme. Consequently, in the case of the TCTModel, this would allow for a more precise translation of stakeholder information. It has become clear during the interviews that clients and vendors do have distinct endorsement cosmoses and care for certain endorsements more than for others.

Figure 2, in contrast to table 1, where each agent receives a structurally equal endorsement scheme, depicts such a typified and weighted endorsement scheme.

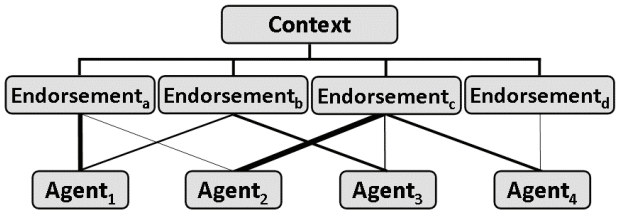

Figure 2. Heterogeneous endorsement scheme. The weight of the lines indicate the importance of an endorsement for an agent.

Although the endorsement's weights e_i remain randomly assigned, they are now assigned within a particular numerical range characteristic of an agent type. In addition, each agent type may have a different subset of the overall set of endorsement tokens.

Continuous Data Formalization

In both simulations, the TCT and the Afghan model, the dynamic character of endorsements is underrepresented. This is because an agent's endorsement process is founded on a discrete (i.e. non-continuous) assessment of the endorsee's endorsements: only the most recent endorsement values are considered. Consequentially, an agent's cognition is based on a binary perception of environment. For the TCT and the Afghan model this leads to undesirable results.

With respect to assessment of clients' satisfaction with vendors' performance over the transaction cycle, the missing temporal dimension led to several problems. The dyad of exchanging partners endorses each other constantly during the whole period of a transaction – in the case of the client, this models the constant monitoring of the vendor's performance and compliance to client's requests, and in the case of the vendor it models the monitoring of the payment duties. In the current implementation it was not possible to express a mediocre satisfaction with the transaction or a satisfaction grade, which would change with respect to the number of performance measures below/above a certain performance threshold.

In the event of the Afghan model the static conception of endorsements leads to a misrepresentation of the dynamic endorsements, i.e. loyal / disloyal, politico-military background, generous / stingy, reliable / unreliable, is-neighbor / non-neighbor, successful / unsuccessful, capable / incapable, recommended / condemn. However, these endorsements should inherently depend on an agent's historicity. The endorser can only endorse the endorsee as being loyal if he has a point of reference that lies in the past and that enables him to compare a previous state with the current state, or if he can estimate the (positive or negative) trend of a number of previous states.

Hence, we suggest an improved procedure that allows for a continuous data formalization. For this, we track the temporal evolution of each dynamic dichotomous endorsement by accumulating the individual values over time. A positive endorsement results in adding 1, while a negative endorsement results in subtracting 1 from the current accumulated value. If no endorsement takes place in a particular time step, the accumulated value remains constant. In the case of the TCTModel, a client may thus monitor the vendor's performance during a transaction that lasts several time steps.

Figure 3 shows the accumulated progression of a particular endorsement for two different agents over time. When choosing between these two the discrete endorsement evaluation process (dashed) relies on a-historic and binary data collection, as it only samples one point in time. The continuous evaluation process (solid), on the other hand, applies a time window and thus relies on experience and multi-valued data sets. Experience

presumes that an agent possesses a "memory" that allows him to collect endorsement data over time as if he would gain knowledge. The time window models an agent's "memory"; its size may be chosen randomly from a numerical range in order to allow for variety among different agents. The collection of multi-valued data implies that the endorser does not only increase his knowledge of the endorsee on the basis of dichotomous variables – is loyal / is disloyal or is generous / is stingy – but is building up his knowledge on the basis of aggregated data.

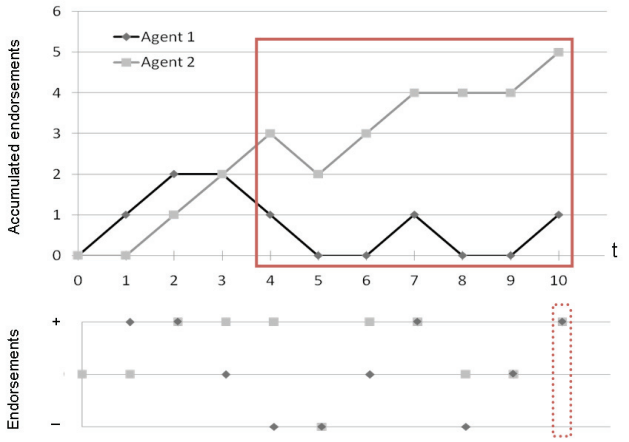

Figure 3. Discrete versus continuous endorsement evaluation process.

Whereas an endorser fitted with a discrete endorsement evaluation process must rely on the information provided by a single "being paid" or "not being paid" statement, an endorser fitted with a continuous endorsement evaluation process can rely on a string of data representing information that has been accumulated over time. Rather than basing his endorsement decision on binary information, he can base it on a trend. Equation (2) expresses this:

$$E_{cont} = \sum_{e_i \geq 0} b_{t_0}^{e_i} \ldots b_{t_n}^{e_i} - \sum_{e_i < 0} b_{t_0}^{|e_i|} \ldots b_{t_n}^{|e_i|} \qquad (2)$$

Since human actors are equipped with a memory and can recall past interactions with another specific actor, the continuous evaluation process is a much more natural way to model human cognitive behavior.

Conclusions

In the presented paper the virtues of endorsements are exemplified by the introduction of two declarative models from the area of social simulation – the Afghanistan conflict model and the model of outsourcing relationships in the banking industry.

Whereas a declarative type of modeling enabled easier implementation of evidence-based qualitative data into our models, endorsements provided a "natural" way to computationally capture the manner agents reason about this rich narrative qualitative data. As mentioned earlier, unlike other simulation approaches, evidence-based modeling pursues constructive validity. For this reason, we were concerned about the importance of the fact that the structures and processes modeled resemble the processes and structures identified in the target system. Thus, the advantage in applying the idea of endorsements was in the fact that they allowed for combining the efficiency properties of numerical measures with the richness and subtleties of non-numerical measures of interest or belief.

Endorsements are used as a differentiated dimensional representation of agent behavior in the presented models and allow for homologue modeling. Furthermore, enhancements suggested in this paper, mitigate inconsistencies of the endorsement concept which became evident during the modeling process, such as the lack of temporal dimension in data formalization and homogeneity of agents.

Although we critically concede that endorsements as representation of real world actor cognition have limitations, we advocate their efficiency in the analysis of emergent socialites in a variety of socio-economic contexts.

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