Trust as an Organismic Trait of E-Commerce Systems

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Abstract. The behavior patterns resulting from the interactions of many trusting entities in e-commerce systems are often more complex than the performance of each of the individuals separately; thus, simple rules of trusting behavior give rise to complex, emergent patterns. A major reason these emergent properties were neither successfully captured nor adequately treated by the current formal models is the global trend of addressing technical issues in a mechanistic manner – considering the system merely as a sum of its components and neglecting the interactions between those components. This work introduces the concept of an organismic property of human-centric e-commerce systems and reveals new areas of applicability of trust as an organismic system-trait. We find that the current schemes of modeling trust in e-commerce systems disregard the role of diversity, complexity, and a service provider's responsibility, concentrating mainly on the relationship among the service consumers. The higher purpose, however, is to provide a novel view of analyzing trust-related design-issues, and to give notice of the possible consequences from a systemic ignorance of these issues in e-commerce systems.

Keywords: trust, e-commerce, organismic, complex, responsibility, context.

1 Introduction

An inherent "misfortune" related to social trust-phenomena in e-commerce and marketing systems is that:

- Trust is generally too complex to be even intuitively grasped, let alone formally analyzed; and
- When it comes to representing its properties through various technicalities and formalities, they are often greatly simplified for the sake of practical feasibility.

Marketing phenomena represent the collective result of many individual entities (consumers, sellers, distributors) whose motivations and actions, although combined by simple behavioral rules, manifest in a manner that produces surprising patterns of global and group behavior [1], [2]. Moreover, these aggregate patterns feed back to affect the individuals' choices. Thus, consumers can make buying decisions based on their acquaintances' advice or their social network's recommendations, which affects the diffusion of products and ideas, and in turn influences the dominance of a brand in

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a market. However, the predominant brands also affect an individual's decisions as to which product to purchase or which idea to adopt. The diffusion patterns that result from the interactions of many entities may be, and in fact ARE more often than not, much more complex than the behavior rules of the individuals. There are many reasons why such emergent properties are not captured and adequately treated by the current computational and formal models. Among those with highest relevance, but also greatest subtlety, is the trend of addressing technical design issues in a mechanistic manner, considering the properties of a system as a whole to be traceable to the properties of its parts. On the other hand, there is another, even more pronounced trend of merging together aspects of systems of different nature into a single operational whole. The purpose is to produce human-centric systems that would integrate the functionality of the emerging technologies with the self-organizing nature of human societies. In its most obvious manifestation, this trend can be viewed in the advent of social networks, electronic services, e-commerce systems, and smart cities, all coming under the umbrella of the Internet of Services and Things. The earlier, mechanistic, view on computational systems is rooted in the engineering contexts in which a system's behavior could be predicted by knowing the behavior of the system's components and their operational ranges. Such systems are, for e.g., the factory plants, or wireless sensor networks, consisting of many devices with known physical characteristics and specifications, and predetermined communication protocols. However, for the later trend, this approach is rendered useless, and moreover, points to a possibility of a serious systemic ignorance if the mechanistic view was to continue. An example for this would be: providing a platform for user to interact, contribute content, and even create new products, but not accounting for how the collaborative, competitive, and monetary elements implemented by the providers affect the users' actions and their interaction with the system.

What constitutes an emergent property; what are the conditions in e-commerce systems that give rise to such properties; how their manifestation affects the system; and what trust has to do with all this; are some of the questions that this work tries to answer. Hence, one of our contributions to the current research on e-commerce trust systems is the detection and analysis of the factors that bear responsibility for the emergence of some unintuitive patterns in those systems. More importantly, our work reveals trust as a core aspect of the solutions for the issues of increased complexity, non-accountable authorities, and user bias.

To meet the stated goals, the paper is organized as follows: we first define some basic terms and give a multi-disciplinary overview of the efforts to tackle trust-related issues in an online, particularly e-commerce setting. As we fit our work into the state of the art, we outline the major issues that dictate the need for an organismic view on trust and point out the significance and benefits of such a view. We then detect new key-roles that trust can play in dealing with the identified issues. Section 4 concludes with constructive summary, pointing towards some future directions.

2 Basic Concepts and Related Work

For the sake of clarity, we now briefly define the basic terms that will be employed throughout the remainder of the paper.

2.1 Basic Concepts

Large body of work have shown and analyzed the intricacies of understanding and making trusting choices [3–5]. Complementing this with what we elaborated above explains the hard time researchers have to incorporate trust into online settings analogous to those from the traditional networks. However, following Gambetta [6], we give:

Definition 1a. Trust is the subjective probability that an entity will perform in an expected and beneficial manner, restraining from doing unexpected harm.

Considering trust only as a subjective probability leaves out risk as an important concept related to trust. This fact has catalyzed a vigorous debate between economists and social psychologists [5]. When one entity relies on another, trust choices are inevitably coupled with risk. Thus, borrowing from Josang [7]:

Definition 1b. Trust is the extent of willingness to depend on others' decisions and actions, accepting the risk of undesired outcome.

Despite the generally interchangeable use of trust and reputation, we differ between the two and recognize the role of reputation mechanisms as technical facilitators for managing trust.

Definition 2a. Reputation is the general standing of the community about an entity's trustworthiness, based on entities' past behavior, performance, or quality of service, in a specific context.

Definition 2b. A system that facilitates the reputation foresight and the trust management is called a reputation mechanism.

Next, we provide an interdisciplinary overview of the approaches for tackling trust issues in e-commerce context, and identify the major issues that will be tackled by our work.

2.2 Related Work

Trust and the Need for Accountable Providers. Significant amount of the efforts for formalizing trust-based interactions employed to design and analyze e-commerce systems is rooted in Game Theory, where concepts like risk, cost, and utility are formally defined [8]. There, the fundamental trust-related problems are captured by the Prisoner's Dilemma; it is a principle that demonstrates the tradeoffs in people's decisions to behave either in their own interest, or in a manner that contributes to the overall community welfare [9]. Prisoners' Dilemma has been extensively used to analyze the incentives for accumulating social capital, as well as the importance of

repeated interactions in inducing cooperation. However, Prisoner's Dilemma *per se* is not able to account for the eventual presence of an 'authority figure' that might impose its controls or affect the decisions of the system entities, regardless of the given payoffs for their actions. Therefore, additional insights are required into how the presence of an *authority* and the actions made by that authority affect the decisions and interactions of the individuals that are part of the same system hierarchy. In the case of e-commerce, it implies a need to account for the strategic games between different service providers, as well as the policies they establish within their platforms, in addition to analyzing the actions of and the interactions between the users. In the effort to account for these issues, we bring to the front another type of Game Theory problem known as the Colonel Blotto game [10]. The Colonel Blotto captures strategic situations in which players attempt to mismatch the actions of their opponents by allocating limited resources across domains in competitive environments. The game consists of the following: two players allocate resources to a finite number of contests (fronts); each front is won by the player who allocates the greater number of resources to it, and a player's payoff equals the number of fronts won. Thus, a player's goal is to strategically mismatch the actions of its opponent. In short, if lower amount of resources are available compared to the opponent, it pays off to increase the numbers of fronts. Despite the desirable characteristics of altruism and cooperativeness in the interactions between two parties, it is reasonable, especially in an e-commerce context, for competition to be analyzed by different means than those used for studying altruistic cooperation. In this work, we attempt to connect such games of strategic mismatch to the current trends of development of e-commerce systems in order to reveal a new role trust can take in e-commerce systems.

Moving the scale from an individual's to a societal perspective, Ba argues that it is often the actions driven by the people's sense of community that contribute to outcomes that improve the community welfare [11]. Moreover, if members are held responsible for their actions, there is a much greater pressure to adhere to the rules. Fehr and Gächter have shown that, if given the opportunity, individuals vigorously punish selfishness, even if inducing punishment is costly [12]. This reveals the potential of trust mechanisms for sanctioning undesired behavior, especially when the possibility of post-contractual opportunism creates a context of moral hazard. On the other hand, distributing the control only among the community members and entrusting them the role of a regulation mechanism of the system evolution forces the system to rely on their subjective view-points, interpretations and actions. Exposing the community welfare to the subjective views of the entrusted members is not a negative thing in and of itself. However, without the means for monitoring and accountability, such an ideology is often considered as the ultimate cause of degradation of the system's work and hierarchy. Makridakis and Taleb have already elaborated on the limited predictability and the high level of uncertainty in various areas of science, and life in general [13]. There is a remarkable body of empirical evidence speaking about the disastrous consequences of inaccurate forecasts that are distinguished by three types of predictions: those relying on patterns for forecasting, those utilizing relationships as their basis, and those for which human judgment is the major determinant of the forecast. Online trust systems are designed to rely on all the three.

Trust and Complexity Reduction. When it comes to traditional societies, one of the crucial roles of trust is reducing the complexity that may arise in social interactions [14]. In that regard, the potential of employing trust mechanisms for dealing with information asymmetry was recognized long ago. As argued above, in the context of moral hazard, trust mechanisms are employed for sanctioning undesired behavior. However, there is another type of information asymmetry, which arises when an entity is required to choose a transaction partner whose behavioral type (for e.g., good or bad) is unknown in advance, i.e., adverse selection. In his seminal work, Akerlof analyzed the effect of social and trading reputation on transaction outcome and market maintenance [15]. He demonstrated that goods with low quality can squeeze out those of high quality because of the information asymmetry present in the buyers' and sellers' knowledge about the products – the problem of the so called "lemon markets". Trust mechanisms would balance this asymmetry, helping buyers make better-informed decisions by signaling the behavior-type of sellers, but at the same time they would provide an incentive for sellers to exchange high-quality goods. Thus, Akerlof makes an instructive distinction between the signaling and the sanctioning role of trust systems, which was only recently considered in computer science [16]. However, all the models that deal with information asymmetry in an online environment rely on probabilistic signals, but also output uncertain values of the variables representing the entities behavioral characteristics. This reveals that it is absolutely non-trivial to determine and appropriately aggregate the different types of signaling information that can be obtained from trust systems. Furthermore, it points to the need to account for the signals from online trust systems through various mechanisms, depending on the nature of those signals. In this paper, we set the ground for how such analyses could be carried out, although we leave the formal justification as future work.

Trust and Collective Wisdom. Despite the significant work done on signaling in economics and contract theory, the online environment poses additional requirements if the same ideas are to be employed. The operation of online market places depends highly on the collective actions of the individual entities (agents, consumers, sellers, distributors, etc.). Incorporating human elements into the technical workings of e-commerce systems leads to the emergence of complex patterns of group behavior that are not necessarily a product of the rules governing the individuals' behaviors. The high discrepancy between the users' expectations and the e-commerce system performance still sustains and is resembled by different forms of bias manifested in the results obtained from the trust systems [17–20]. However, biased results may not come from biased inputs by the individual entities. The whole chain of dependencies in the e-commerce system has to be considered to determine the causal loops that appear between the system inputs and outputs and to prevent reinforcement of this bias in a cascade manner. Our work will establish the bond between computational trust and the exploitation of "the wisdom of crowds" in e-commerce systems [21]. Moreover, it will detect the detrimental role of dependent and non-diverse opinions in exploiting the benefits of "the wisdom of crowds" and the emergence of user bias.

Despite the early work on trust relations and conflict resolution in Game theory, the notion of computational trust appears significantly later, when Marsh established its formal basis in distributed artificial intelligence [22]. Although distinguished by its simplicity, Marsh brings the substantial finding about the agents' tendency to group into robust clusters with similar trustworthiness and interests. However, he makes no distinction between groups and individuals and the different properties they exhibit, considering groups as entities that equally encounter and resolve trust choices as the individuals comprising them. Thus, the micro-behavior of the system entities are considered to resemble the macro-effects of the overall behavior.

The following section introduces the notion of an *organismic property* of trust systems, analyzing its importance for the design of human-centric e-commerce systems dependent on the trusting choices of their entities.

3 The Organismic Nature of Trust

In a previous work of ours [23], we analyzed trust systems through the General Systems Theory [24]. Based on the Jordan's System Taxonomy [25], we categorized trust systems as *functional*, *organismic*, and *non-purposive* (Table 1), and showed the implications of such a categorization on the overall system's functionality.

Table 1. Organizing principles of Jordan's Systems Taxonomy (bolded and italicized are the categories to which trust systems are ascribed)

Rate-of-change	**Purpose**	**Connectivity**
Structural (static)	Purposive (system-directed)	Mechanistic (non-densely connected)
Functional (dynamic)	***non-purposive (environment-directed)***	***Organismic (densely connected)***

Here, we concentrate on the organismic property of trust systems, as we consider that the trend of neglecting it endangers the sustainability of any human-centric system, of which e-commerce systems are a major representative.

A main characteristic of *organismic* (or densely-connected) systems is that they change even when a single connection between their components changes. In contrast, *mechanistic* systems are not affected by the removal of parts or connections in the remaining components. Remarkable proofs of the organismic nature of social systems can be found in Granovetter's threshold model of collective behavior [1], and Shelling's models of segregation [26], both of which show the mismatch between the micro-behavior of the individuals and the macro-effects that appear as a result.

E-commerce trust systems depend highly on the entities' choices and interactions. Their complex nature makes it extremely hard, if not impossible, to predict the impact of these interactions on the system performance. The different types of entities and their differing interests require for each design issue to be analyzed from multiple perspectives.

We now proceed with presenting the major scenarios that dictate the need for an organismic approach of designing trust systems for e-commerce purposes, and define the role that trust plays in tackling the encountered issues.

3.1 Reduction of Complexity

Luhmann has long ago recognized trust as a means for reducing complexity in traditional social systems [14]. However, it is not that trivial to generalize this as an implication for online systems, which are much more dynamic and especially more scalable. Although most of the proposed trust models provide some discussion or evaluation of their scalability (among other performance criteria), scalability is mainly considered a technical nuance of a given solution and is analyzed separately from the interactions between the system entities. However, it is clear that no system can grow infinitely. Thus, the life-span of the natural (organismic) systems spreads through two major and subsequent phases: growth and maintenance [27]. The resources systems use in the first phase are mainly intended for growth; in the second phase, on the other hand, the systems' resources are employed for maintaining the state and preserving/improving the quality of operation (a quick recall of the human as a system would suffice to realize this). This transition from quantity to quality-based operation is often seamless, prospectively unpredictable, and only retrospectively realizable, which is why the mechanistic trend of resolving systemic issues continues.

Hence, the question arises: following Luhmann's view of trust as a means for complexity reduction in a society, can we detect ways in which computational trust reduces complexity in e-commerce systems? One thought in that direction is reducing the complexity of negotiating a transaction, as having a trust system in place implies: finding someone (or information about them), looking at the community's standing (as a signaling device) about their reputation, and deciding whether to transact or not without any prior interaction. But in addition to reducing the complexity, it is clear that it is also the **cost** of negotiation that is reduced, as the protocol of starting a transaction is significantly simplified. However, this holds only if the information is accurate enough, and is also considered reliable by those who should act upon it – in other words, if entities are able to trust the trust information. Therefore, it is not sufficient to only decide what type of information should be loaded into the aggregation mechanisms that compute trust, but also to provide mechanisms that show if the information generated from the system is perceived appropriately by the users. In our future work, this concept will be formalized using a framework of *interpreted and generated signals* [28], which will allow matching the adequate types of trust signals with the various contexts of embedding trust-information in e-commerce systems.

3.2 Enrichment and Diversity

The consumer preferences are directly related to the marketing strategies of the service providers. The change in the former often imposes necessary change in the

later. However, users are often unaware of their taste, even for experiences from previously felt outcomes [3], [4], [29]. Not only does this mean that taste is much more subtle than preference, but it also shows that preference itself is not a stable property of human reasoning [30]. In online trust systems, experiments on persistency of user preferences about identical items at different instances of time proved significant fluctuation in the repeated preferential choices [31]. To preserve the dynamics of fluctuating preferences, it is important that an e-commerce system maintains diversity in terms of market strategies, choices offered to their users, the users' behavioral types, their opinions, and the actions they undertake. Surowiecki included diversity as one of the key criteria crucial for exploiting the so called "wisdom of crowds", together with independence, decentralization, and aggregation of opinions (Table 2) [21]. Although deceptively different, the same analogy holds for evolutionary phenomena; namely, that fertilization leads to enrichment (of a certain species), but also to the loss of diversity of species [27].

As discussed in the Related Work section, a great deal of research has shown that the following major issues are common to all e-commerce systems:

- The largest percentage of provided resources comes from the minority of users [19], and most of the users act only as "content-consumers", providing negligible amount of resources [32];
- Small number of system entities drive the general population's opinion [17];
- The presence of the so called *herd behavior* or *bandwagon effect* [3] is manifested as a group polarization in the individual's online actions [33];
- The aggregated results from the feedback mechanisms (through trust and reputation metrics) exhibit a high level of positive bias, even in their steady state [18];
- The marketing strategies employed by the companies and media are very often directed towards creating such biased effects in order to gain a large percentage of consumers (be it tangible goods or content as a product) [34], [35].

Table 2. Key criteria that separate wise crowds from irrational ones

Criteria	Description
Diversity of opinions	Each person should have private information even if it is an eccentric interpretation of the known facts
Independence	People's opinions are not determined by the opinions of those around them
Decentralization	People are able to draw on local knowledge
Aggregation	Some mechanism exists for turning private judgments into a collective decision

By mapping the above issues onto Table 2, the following can be observed:

- Current trust systems do allow for obtaining a local view on the entities' knowledge about the behavioral types of their transaction partners, thus ensuring **decentralization** in the process of inferring trust;
- There is a significant body of work on defining a formal apparatus for **aggregating** trust information. Subjective Logic is among the most prominent, and also one that resembles many of our views about what constitutes a suitable way to cope with the subjective nature of trust [36];
- However, the manifestation of group polarization and user bias as a steady-state phenomenon in all the e-commerce systems that are equipped with trust mechanisms implies a clear lack of diversity, and moreover – lack of independence in the entities' actions (including opinions, decisions, etc.).
- Finally, the marketing strategies of the various companies and the media additionally amplify the effects of initial mismatch between the users' expectations and online services, contributing to cascading effects of biased behavior resembled by the bandwagon effect.

All of the above observations are a strong testimony for the organismic nature of e-commerce trust systems, as they all show that a single action or change of the systems entities can have a huge impact on the overall system behavior and performance. They also show that exploiting the wisdom of crowds can be strongly inhibited by the externalities that the human element brings into the trust system. This, together with the causal loops through which user bias is amplified in the system [37], point to the need of more subtle mechanisms for capturing trust as an emergent, and not an inherent entity's property.

In a recent work of ours, we performed experimental studies of the factors that influence the users' actions and decisions in online reputation, rating and recommendation systems [38]. We found that increasing the granularity of the Likert-scales (analogous to increased diversity of offered user-choices) and adding a "positive spin" to the presented choices for user evaluations in e-commerce systems can act as an incentive for providing more diverse, but also more accurate feedback. These findings and the theoretical analysis presented in the current paper provide a framework for the formal modeling and analysis of diversity as a requirement for efficient trust systems. This formal model will have as its foundation the Diversity Prediction Theorem [39], which connects the crowd's prediction error to the individuals' prediction errors and the crowd's diversity.

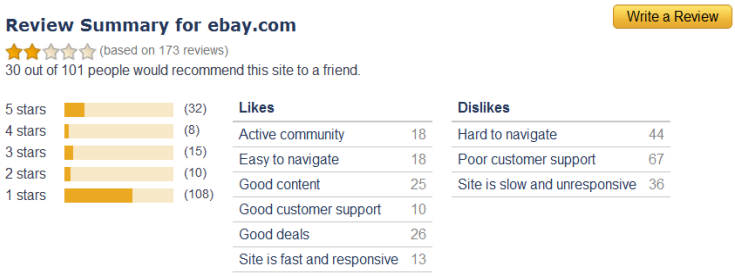
3.3 Provider's Accountability

In this section, we connect the notion of 'strategic mismatch' represented by the Colonel Blotto game [10] to the current development trends of e-commerce systems and determine the benefits that the accounting for the provider's trustworthiness have for trust elicitation. To do that, we analyze some microeconomic strategies in e-commerce systems, identify the need for a distributed responsibility scheme, and establish trust as a basic accountability measure to respond to this need.

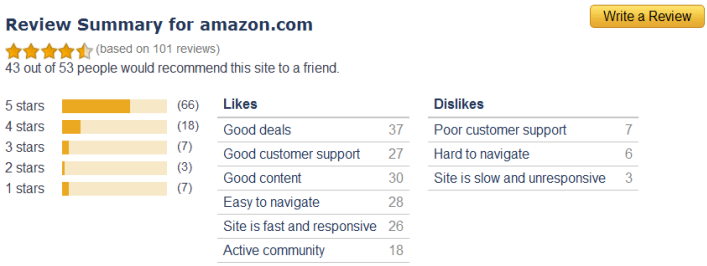
Since the basic setting of Colonel Blotto defines a zero-sum game (one party's benefits equal the other party's losses) in which the winner gets everything, and requires that the opponents have equal amount of resources, using the original model would be misrepresentative of the true nature of market interactions. Therefore, the reasoning employed here follows the generalized analog of Colonel Blotto - "General Blotto game" [40]. General Blotto's trait of realism lays in the fact that it allows that an opponent has advantage in the number of resources available. Furthermore, it accounts for the additional externalities that can affect the game flow, such as changing circumstances and non-independent fronts. Finally, it extends to an arbitrary number of N players, unlike the original game defined for two players. Because of space constraints, but also because the formal approach deserves special attention and more in-depth justification, we leave these analyses for a subsequent work. In what follows, we directly give our analysis based on the insights from the General Blotto game, but we refer the interested reader to [10] and [40] for justification of the reasoning included here.

Amazon[1] and eBay[2] are the two largest e-commerce companies, and according to the Web Information Company Alexa[3], their sites are also the two top-ranked e-commerce sites (with overall rank of 10th and 21st place respectively). Among the 100 top-ranked sites, there are only four to five e-commerce sites (this number varies on a daily basis). With highest rank are the ones that are not constrained to a unique product offer (books only or movies only) and that provide a wide specter of products and services. These statistics of the general standing of e-commerce sites among other site-types shows that only a handful of e-commerce sites are prevailing on the Internet. Intuitively, this resembles the network effect of the economies of scale, and is arguably similar to the same effect in the traditional world: big stores squeeze the little stores out of the market by providing a more stable and a more convenient offer with a wider range of available products [41]. This is also the reason that we connect these providers' strategies to the games of strategic mismatch. Thus, the same products on Amazon and eBay have been put within a different range of contexts (i.e., fronts), which creates an opportunity for them to be valued differently by the consumers. For example: on Amazon, a book is possible to be published by Amazon, reviewed on Amazon, rated, recommended, sold, bought, stored and backed up, made available on Kindle, shipped by Amazon, processed in some desired way through Amazon's Mechanical Turk[4], etc. On eBay, on the other hand, the same book can be sold, maybe bid for, bought, rated, or shipped (by a seller). This shows two different strategies of allocating the same resource over various contexts, and has proved to affect the companies' revenues in a different manner. However, it is not only the revenues that are being affected. To support our reasoning, we extracted the concrete feedback about the user's satisfaction from Amazon and eBay. Figure 1 shows that, despite the high popularity of the two companies, the general estimates of their platforms differ to a great extent.

[1] http://www.amazon.com/
[2] http://www.ebay.com/
[3] http://www.alexa.com/topsites (this list is based on one-month average traffic rank).
[4] https://www.mturk.com/mturk/welcome



a)



b)

Fig. 1. Alexa review summary for a) Amazon and b) eBay

This is not to illustrate a lower reputation of eBay compared to Amazon; the purpose of the two systems differs sufficiently for them to be incomparable to one another in many aspects. However, the high percentage of positive feedback and the users' reluctance to leave negative feedback within the eBay and Amazon platforms [17] [20], points to a discrepancy between the users' adoption of e-commerce services, their satisfaction of those services, and the feedback they provide within the platforms that offer the services. Considering that trust is an emergent property of a system, and a system designer can only provide the circumstances under which trust can flourish, it is reasonable to state that the basic type of trust required for a functional system is trust in the platform provider. Current trust models do not consider combining this form of *accountability trust* with the trustworthiness traits of the system entities. Yet, there have been important arguments for the benefits that such an approach can have for the reliability of both security systems [42] and socio-technical systems [43]. This intuition was confirmed by simply querying the web for the "top 25 e-commerce sites". The top two results showed that the user preferences are much better inclined for more specialized sites, with respect to both their offer and their design[5]. Hence, considering such accountability trust as an implicit feedback can provide a distribution of responsibility among all the system entities, including accountability for the

[5] http://kaleazy.com/top-25-best-e-commerce-sites-of-2011/, http://www.smashingmagazine.com/2010/01/22/35-beautiful-and-effective-ecommerce-websites/

service providers. This is especially important as e-commerce systems scale up, because in the transition from growth to maintenance, trust will increasingly act as an emergent qualitative signal.

3.4 Discussion

The analyses in this paper contribute to the well-known debate on how people are tuned to think in terms of linearity: to expect growth where there has been a long trend of past growth and to assume double output if there was doubling in system's input. While it is apparent that an organism or a human does not grow infinitely, it is also reasonable to assume that a five-year old (human) is not half a ten-year old one. Also, maintaining a city that has doubled in size requires more than double of the resources spent before its growth, as there is an additional cost of maintaining the interconnections between the system components. The same stands for any human-centric system, regardless of whether it is technical, social, or hybrid. The inclusion of the human element acts as an opening valve of the system towards its environment of deployment, adding complexity in the way the internal structure of the system is maintained. This gives rise to the ascribed non-linearity, expressed as 'the whole not being equal to the sum of its parts'. Thus, an organ exhibits additional properties to those of the cells that comprise it, a human is not a simple sum of organs, a city is more than the sum of its households, and a technical system is neither a mixture of nodes, nor just a union of agents. Among the properties that emerge from the interactions between these entities, trust takes a central place in maintaining quality as the system scales up.

However, it should be stressed that neither of these properties is possessed by an entity in isolation of its environment, or of the rest of the (entity's) world; all of them emerge from the entities' interactions in a particular context, at a particular instance of time, under particular cognitive and affective dispositions of the interacting parties. In the same manner, although we can speak about trust relationships between technical systems entities (humans, agents, items, peers, etc.), we should not ascribe to any externality the role to breath trust into a computational setting, or to any internal force the right to preset an entity's disposition to perceive or act upon trust. Otherwise, we would sacrifice the natural diversity that arises in an organismic system, and inhibit the diffusion of opinions and ideas that the system could cherish. Although we may recognize the external and internal factors as such, it is the entities' awareness of the contextual traits of their environment that will determine their trusting abilities and allow the emergence of trust per se. It would not be an exaggeration to therefore state that a mature e-commerce system is one that accounts for the trusting phenomena emerging from and joining the entities' transactions. Moreover, the efforts to capture these trusting phenomena must also exhibit awareness for the responsibility schema of the actions of all involved entities, regardless of the hierarchical level they have in a system.

Clearly, the interdependency between the human factor and the trust system operation requires additional, more exhaustive and cross-disciplinary research that will confirm and extend the analyses presented here across other types of online systems as well.

4 Conclusion and Future Work

Despite presenting a multidisciplinary overview of the efforts to tackle trust-related issues in e-commerce systems, this work pointed out the significance and benefits of seeing trust as an organismic trait of e-commerce systems. We revealed novel roles that trust can play in dealing with the issues of complexity reduction, diversity of crowd's opinions, and responsibility distribution, and pointed to the providers' trustworthiness as an important property that should be considered as e-commerce systems transit from scaling to maturing. Finally, we again stress the futility of incorporating trust as an inherent property of online system entities; it is only reasonable to think of creating the conditions under which trust can emerge and flourish. Context is, therefore, a major factor that would inevitably gain attention in the design of future computational trust systems.

Although this paper is more a taxonomy of identified factors rather than a modeling effort, it nevertheless bares crucial importance in establishing the borders within which the formal resolution of the problems addressed here is meaningful to be done. All of the identified issues are, therefore, lendable to formal modeling and justification, which will be provided in a consequent and broader study of each of the topics outlined here.

Our future work will also consider an agent-based approach of modeling and resolving trust-related issues in e-commerce systems. Continuing on the same "organismic" note, we will explore the role of redundancy and distribution in the provision of robustness of trust systems, and formalize diversity and conflict as a means for dealing with the issue of user bias. This is especially significant if we recall that a small number of entities drive the public opinion, implying that although current e-commerce systems are robust to failure, they are extremely fragile to targeted attacks.

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