International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:1, No:2, 2007

The Socio-Technical Indicator Model: Socially-Sensitive CMC Technology, with an Implementation of Representative Moderation

Zach-Amaury Boufoy-Bastick, Lenandlar Singh

Abstract**—**Computer-mediated communication technologies which provide for virtual communities have typically evolved in a cross-dichotomous manner, such that technical constructs of the technology have evolved independently from the social environment of the community. The present paper analyses some limitations of current implementations of computer-mediated communication technology that are implied by such a dichotomy, and discusses their inhibiting effects on possible developments of virtual communities. A Socio-Technical Indicator Model is introduced that utilizes integrated feedback to describe, simulate and operationalise increasing representativeness within a variety of structurally and parametrically diverse systems. In illustration, applications of the model are briefly described for financial markets and for eco-systems. A detailed application is then provided to resolve the aforementioned technical limitations of moderation on the evolution of virtual communities. The application parameterises virtual communities to function as self-transforming social-technical systems which are sensitive to emergent and shifting community values as products of on-going communications within the collective.

Keywords**—** virtual community, e-democracy, feedback systems, moderation.

I. Introduction

In recent years, a growing literature has emerged on interest-oriented relationship systems within virtual communities (Li, 2004). Yet, although much research has been conducted on interactions within such communities, and on their impact to their external society, little has been published on how representatively the virtual community structures reflect the social structure of the external community. Indeed, computer-mediated communication technologies, which provide for virtual communities, have typically evolved in a cross-dichotomous manner, with technical constructs of the technology evolving independently from the social environment of the community. Hence, technical mechanisms of virtual community, such as moderation, are generally insensitive to the social structures within the communities in which they operate. Such technical mechanisms have come to depend heavily upon the external agency of community members to sensitize the socio-technical environment of the virtual community. As this paper will evidence, these social-technological limitations have typically resulted in virtual communities having to use inflexible unrepresentative communication environments which have, in turn, limited their evolution and restricted their options for growth. In order to resolve these limitations, a Socio-Technical Indicator Model has been developed that simulates generalized integrated community feedback systems. The general model is presented and shown to have applications to structurally and parametrically diverse systems as varied as financial markets and eco-systems. Finally, the model is applied to the moderation function of virtual communities, resolving traditional limitations by operationalising the virtual community as a self-transforming social-technical system, sensitive to emergent values as products of on-going communications within the collective.

Authors are with the Université de Paris IV Sorbonne 136 Rue de Vaugirard 75015 Paris France. Tel: 0147343430 (e-mail: zach.bastick@gmail.com).

II. Background of Previous CMC Models

Mechanisms of moderation and representations of user status are two inherent concepts of virtual community, each of which has generally evolved independently of the other. A categorisation that is sensitive to this dichotomy can be assumed, such that the prior is viewed as a technical concept and the latter as a social concept. However, this is a crossed dichotomy in that moderation has typically evolved as a technical component which operates *a priori* on the social environment in which it is applied and, conversely, status representation is largely a social component, which typically has implied little bearing on the technical workings of the community. In order to contextualise this crossed dichotomy, a background review of moderation mechanisms and status representation, which illustrates this crossed dichotomy by their respective sensitivities and flexibilities to the communities they have served, is now presented.

In itself, moderation has typically been restricted to the political science equivalents of absolutism or oligarchy. That is, throughout the evolution of virtual communities, moderation has generally been the responsibility of individuals within the community, selected through circumstance or relationship rather than as functions of the community itself. Perhaps, the earliest instance of such moderation occurred over the ARPAnet, the first wide-area network funded by the Department of Defence's Advanced Research Projects Agency (ARPA). This network, which started as a single Interface Message Processor node at the University of California at Los Angeles in 1969, eventually grew to include nodes at the Stanford Research Institute, the University of California at Santa Barbara, and the University of Utah (Zakon, RFC2235, 1997). Due in part to the largely homogeneous and exclusive nature of its users, moderation existed as an informal and ill-defined function. Although no technically-defined moderator class was established within the early ARPAnet, the role was fulfilled, at least on one occasion, by ARPA officials[1]. Hence, ARPAnet moderation was an informal property of an institutional affiliation. Later, through an evolutionary shift paralleled by the lowering of entry boundaries and the popularisation of computer-mediated communication, a moderator class became an inherent component of synchronous systems, such as Internet Relay Chat, as well as of asynchronous systems, such as Netnews and modern-day web-based forums. Usenet saw the birth of the built-in moderation apparatus which, unlike the ARPAnet, offered a formal mechanism of moderation for localised communities. Now, modern-day web based forums also offer similar formal moderation mechanisms.

In post-ARPAnet communication spaces, the translation of social values to technical moderation was achieved, to a certain extent, by the adoption of norms of discourse, collectively referred to as netiquette. Netiquette rules, such as those outlined by Rinaldi (1998), provide generally accepted policy as well as subtle local community conventions, which users are expected to observe during discourse. Communities generally provide an Acceptable Use Policy, or a Charter containing netiquette rules for their members to observe. The burden of moderation is, hence, extended to interlocutors within conversation spaces. For example, users within a Usenet environment may be expected to avoid capitalizing an entire line of text or indiscriminately cross-posting (Whittaker**,** *et al*., n/d, p.1). Nevertheless, such discourse decorum is often ignored by discussion participants (Kollock and Smith, 1996). Cross-posting, for instance, is frequent in Usenet newsgroups (Whittaker**,** *et al*., n/d, p.6). In cases where breaches of netiquette do occur, community moderators are typically burdened with editing the post or contribution. Even so, whether moderation occurs on an interlocutor basis or a moderator basis, guidance by netiquette implies a heavy dependence upon the interpretation of Acceptable Use Policies and Charters. However, this necessary reliance on interpretation is fettered by the very nature of virtual environments. For example, in wide-area systems such as Internet Relay Chat, where concurrent conversations may occur within the same conversation space, messages are, however, displayed in a sequential order. Hence, it may be difficult for users to maintain coherent and sustained topical conversations.

Virtual communication generally also denies interlocutors the use of the social cues which have central regulatory functions in face-to-face communication. In contrast to face-to-face communication, where social meanings of an interlocutor's identity are embodied within their communication acts, the virtual world of large-scale communication is largely a textual and disembodied one. Hence, some of the mechanisms which traditionally anchor identity and stabilize conversation are not present within virtual communication spaces. Within such a context, it is not always appropriate to rely upon individuals, generally of a single conscience, to moderate for the benefit of the entire community. Instead, a few communities apply 'team moderation' in which a sub-section of the community moderates for the entire community. The sci.med.aids group, created on June 13, 1987, applied such a form of moderation. Moderators of the group, maintaining distinct roles such as 'chief moderator' or 'expert contributor', communicated via electronic mail in order to reach consensus on issues of moderation (Greening, 1988, p.1). Among further benefits[2] such as efficiency, well-formed team moderation allows for more representative moderation systems which can reflect the opinions of both the majority and marginalized subsections of the community. Conversely, badly-formed team moderation may be no more representative than individual moderation since, as Benjamin Franklin so eloquently wrote "when you assemble a number of men to have the advantage of their joint wisdom you inevitably assemble with those men, all their prejudices, their passions, their errors of opinion, their local interests, and their selfish views" (cited in Farrand, p. 642).

Given that any team of moderators can be jointly biased by excluding representation of their community, the benefits of team moderation may lie exclusively in its efficiency. Thus, although netiquette rules may be democratically formulated by the community, the interpretation of the rules may be fettered by the nature of the medium of communication or through collective bias. More importantly, however, is that community norms and decorum are external to the technical existence of the communication median. This dichotomy between social standards and technical moderation may restrict flexibility; that is, virtual communities may become severely limited in their capacity to evolve, in that they can only evolve by the external agency of human administrators. For instance, in situations where the focus and interest of the general community shifts, whilst the focus and interest of the moderators does not, or where social changes are not paralleled by changes in Charter, virtual communities are denied the flexibility of evolution.

In order to increase social sensitivity within communication technology, many communities technically value 'user contribution' as a direct equivalent of the social construct of

[1] For instance, ARPA formally responded to the Digital Equipment Corporation's commercial mass-mailing of May 3rd, 1978 – referring to it as a "flagrant violation of [the terms of use of] ARPAnet" (cited in Templeton, n/d) and stating that "appropriate action is being taken to preclude its occurrence again" (cited in Templeton, n/d).

[2] For statements on the additional benefits of team moderation, *See:* Greening (1988, pp.6-9) and Landfield (2001, module 10).

user status. For instance, a few popular forums apply a social ranking system based on user post-counts or other criteria. In such systems, wherein posts are generally statically-valued (i.e. where each post is assigned a constant value), a user's status is defined as the sum-value of all their posts. An example of such a forum is the popular, open-source, phpBB forum software (phpBB, n/d, p.29). Such ranking systems have few technical implications for the user[3], but rather aid in the establishment of a technically-represented social hierarchy. In building socio-technical hierarchies, other communities distinguish between various types of contribution and value each type separately. In a study of the music-oriented WholeNote and ActiveBass communities, Kelly, Sung, *et al*. (2002) notes that 'point totals' are assigned to members based upon their contributions. Point totals are incremented by set values based upon the nature of a contribution. For example, 'publishing a lesson' increments a user's point total by ten points, whereas creating a 'home page' increments a member's point total by twenty points (Kelly, Sung, *et al*., 2002, 394). A user's point total reflects their membership status within the community, consistent with the implied community value that 'more productive members being more highly considered'. Indeed, such a system may increase contribution as users' ability to influence to community increases the sense of community that any user feels within the virtual environment (Blanchard and Markus, 2003), and such an ability may be associated with content contribution. The Slashdot model employs a similar system, at least to the extent that comment descriptors, such as 'off topic' or 'insightful', each correspond to a set positive or negative unitary value (Lampe and Resnick, 2004, p.2). Yet, as with the static-valuing functions of popular web-based forums, this is a functional model for these specific communities and can not easily be generalised to serve values of other communities. For instance, not all communities may provide home pages to their members, and those which do may not consider the creation of a homepage to be worth twenty points. More importantly, however, is the dilemma of how one initially chooses a concrete value, such as 'twenty-points', and who should make such a decision about valuing the resources of an entire community. Further, the model suffers from the same restrictions on flexibility as Netiquette-based moderated communities, since the resource valuing function is external to the social state of the community.

Moderator interpretation, ambiguous Acceptable Use Policies, collectively biased and unrepresentative moderator classes and the creation of socio-technical hierarchies based on inflexible resource-valuing functions are complications which are typically shared amongst current virtual community models. The underlying characteristic of these communities, at least within the context of moderation, is that social constructs are rarely combined with technical constructs but, rather, social environments evolve around the community's technology. In communities where such constructs are combined, external human agency generally acts as bridge between the technical workings of the forum and its social environment, and, as illustrated, the technology is generally neither sensitive nor flexible to the evolving social states of the communities it serves.

[3] Exceptions do exist, such as the applied use of post count and rank in order to allow access to certain private sections of a forum. Moreover, a similar user segregation mechanism, called 'grouping', allows users certain access privileges on specific forums; being a member of a private group hence entitles the user to view and post in forums that non-group members would not have access to (phpBB, n/d, pp.11-12).

III. Mapping Community Functions to User Status

In order to provide for more technically sensitive and flexible developments of virtual communities, it is appropriate to provide an operational *socio-technical* model that merges social and technical constructs of community environments. Within this context, community functions can be shifted from purely peripheral social constructs, such as externally valuing community resources, selecting usage decorum or assigning privileges based upon relationship or circumstance, to technical constructs which are representative of the social state of the community. In order to create such generally applicable sensitive and flexible technology, any single social characteristic of a community that can be evaluated, assessed and valued, should be capable of an isometric mapping to a related technical function and parameter of the model.

Thus technical functions should allow for sensitive and flexible simulations of community functions that maintain moderator privileges only to the extent that they promote community values. For instance, moderators burdened with classifying contributions in a humour-oriented community should be positively valued by the community for their ability to classify types of humour. These values can be gathered from contributions or processes. Further, if the community's perception of the moderators' ability to classify humour degrades over time, to such an extreme point where the moderator is no longer viewed as socially fit for such a position, then their technical privileges should be removed or the moderator should be replaced. This presents two possibilities for moderator assignment. Firstly, moderator privileges related to a valued social characteristic could be assigned to any willing members of the community, who have the highest status for that characteristic. Secondly, moderators could be assigned in a typical external fashion - through the agency of community members. In either of these cases, the system remains flexible and allows for community evolution in that moderators must satisfy the community, thus providing a minimum level of perceived benefit or value, in order to retain their privileges. Central to the realisation of such a system, is a model which allows for sensitive representation of community satisfaction, resource value and user status.

IV. Community Characteristics and their Evaluation

Virtual communities differ in focus and, consequently, do not all value common characteristics, like resources and aspects of participation, in the same manner. Activities such as trolling, flaming, spamming, and flooding benefit some whilst impeding others (Lampe, 2004, p.1). Flaming, for instance, may allow the open express of emotions, but in doing so decrease message structure (Mabry, 1996), thus fettering the interpretation of the flame's recipients. Similarly, lurking may satisfy the personal and informational needs of a user whilst acting as a hindrance to public participation and as system overhead (Nonnecke, *et al*., 2000). In addition to multiple forms of user participation existing individually within a virtual community, specific communities might value one characteristic of participation more than another. An official news outlet, for example, might favor postings by only privileged members and thus encourage general lurking, whereas a community based upon academic discussion might favor deliberative discourse and debate. In building a status-oriented virtual community based upon valued aspects of participation, one hence has to consider a valuing function for various aspects of participation. Computer Science studies have, generally, adopted a defeatist solution of valuing aspects of participation *a priori* to the community. In a theoretical study on community activity level, for instance, (Barry, Dekel, *et al*., 2003, p.4) state that "a community derives little or no value from a user who simply reads messages". Other studies, such as (Ludford, Cosley, *et al*., 2004), avoid the complication altogether by operationally defining participation as being only 'visible content contribution'. Furthermore, opinion of resource value may differ between members of a community. For example, Cosley, Frankowski, *et al*., in meta-commenting on their study, state that "…we called a newbie question a low-value contribution. But for the asker, for lurkers with the same question, and for members who want to demonstrate their knowledge, the contribution has high value" (Cosley, Frankowski, *et al*., 2005, p.19). Since opinion of resource value differs amongst, and within, communities, it is inappropriate to adopt an *a priori* approach to valuing contribution in a generalized community model. Rather, a generalized community model must allow options for systematically rating contributions and valuing individual users with respect to valued social characteristics, in some cases taking into account the values of individual members and special interest groups (SIGs) within the community.

The social environment of a community is likely to comprise multiple social characteristics. Hence, simulation functions are identified in order to evaluate assessable attributes that relate to community. In a technical context, the value of an attribute can be a property of a user contribution, such as length of a post, or it can be a property of user participation, such as the time between posts. In relation to contribution-specific attributes, for example, a given community may wish to measure the attribute of 'contribution quality' in order to modifying user status. In a study of Lotus Notes databases, Whittaker (1996) qualitatively identified computable aspects of virtual discourse. Specifically, he identified 'mean conversational thread length', 'Mean percentage of dead-end conversations', 'Mean Browsing (read/write ratio)' and 'Read Rate (mean reads/day)' as valuable measures of conversation quality (Whittaker, 1996, p.415). These measures lend themselves not only to Whittaker's 'conversation quality' but also, through an associative connection, to the quality of posts by users, as well as to other measures of user contribution. Any other measurable characteristic of discourse, such as aggressiveness or level of profanity, could also be adopted by an implementation of the model. In terms of user processes, a community that is conscious of lurkers might find it appropriate to identify the time between user posts, or the frequency of users' posts, as measurable attributes of participation. From such foundational attributes, it is possible to build an interconnected technical representation of the community's values which determine its social structure, vis-à-vis both community values and user values.

V. Conceptual Framework of the General Socio-Technical Indicator Model

The conceptual framework for the general Socio-Technical Indicator Model is illustrated in Figure 1, in which a generalised characteristic of the community *j* is measured within the community. The model can be viewed as a feedback system, in which a user value, such as status or wealth, is altered through direct and indirect effects of system components. The high-level effects which define the Socio-Technical Indicator Model are illustrated in the meta-model, presented in Figure 2. In order to maintain generalizability, six formulas are used, each of which can be defined so as to simulate various characteristics of representative systems. Indeed, the model is capable of simulating many systems, including financial systems (e.g. stock markets, commercial sales, etc.), bio-conservation systems (e.g. species evolution, wildlife extinction, etc.) and moderation systems for virtual communities. Whilst the application of the model to these systems is detailed in Table 4 and a brief explanation of each application follows, the focus of this article will remain on applications to moderation.

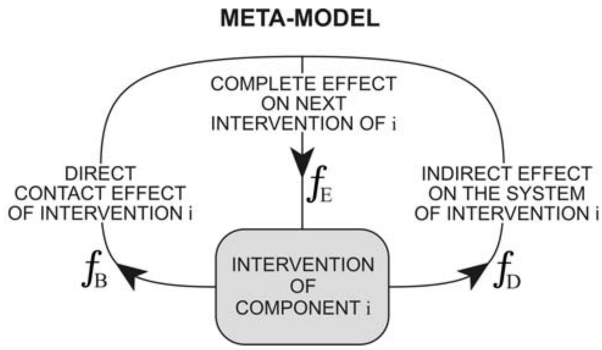

Fig. 2 Socio-Technical Indicator Meta-Model

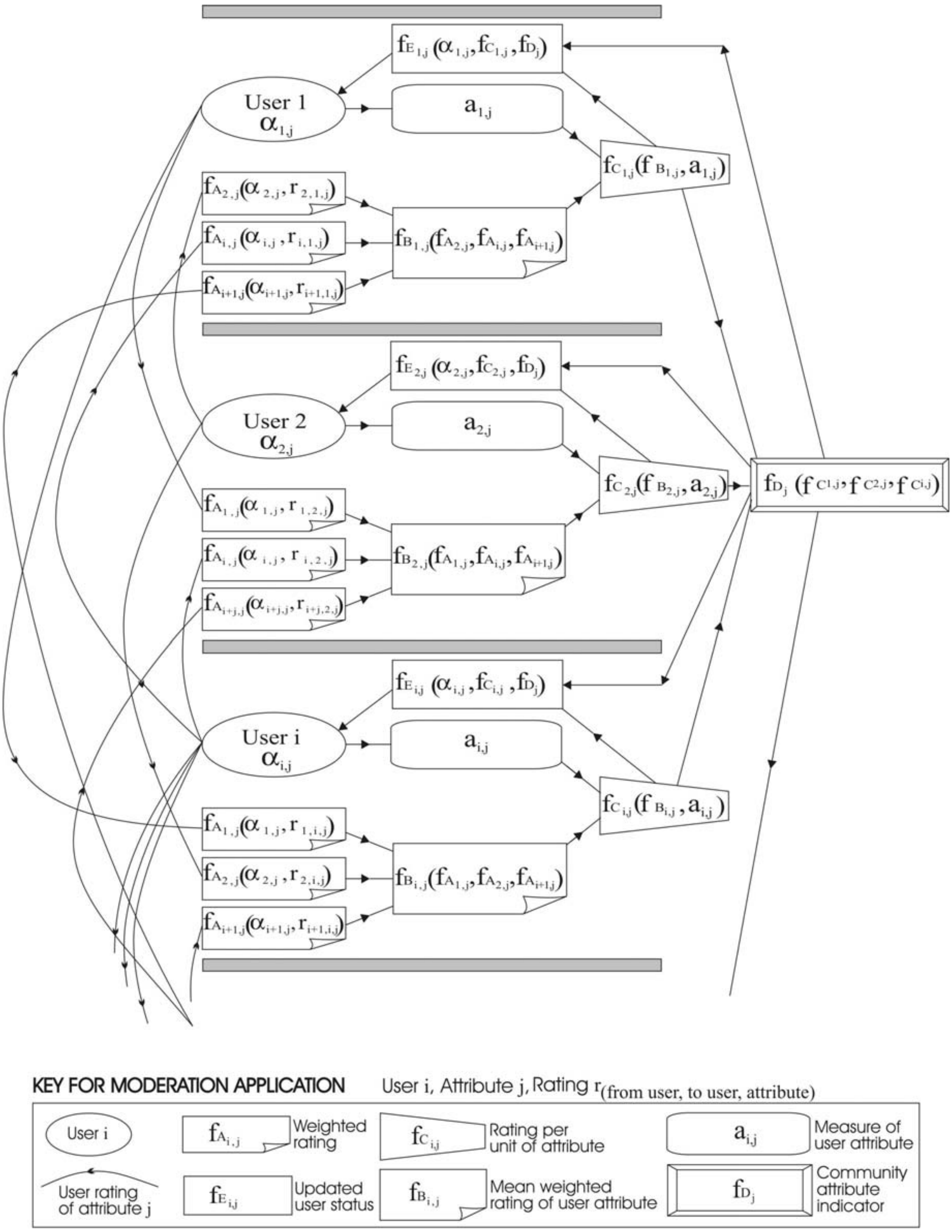

Fig. 1 Conceptual Framework of the Socio-Technical Indicator Model

Within the context of moderation, a social characteristic is technically represented by a measurable attribute, j. Hence, the generalised user, User *i*, is associated with a measure, $a_{i,j}$, for any attribute *j*. For instance, if *j* is the 'profanity', then $a_{i,j}$ represents the actual count of occurrences of profanity within User *i*'s contribution. Opinions of the measure $a_{i,j}$, are then collected as ratings from other users and weighted by their respective status, or $\alpha_{i,j}$, which is dubbed the *user socio-technical indicator* for User *i* and the attribute *j*. Each $\alpha_{i,j}$ is iteratively modified by both the weighted ratings which the

User *i* receives for their measure of attribute *j* (e.g. how much the community values their contribution or processes) and by the community's general rating of the attribute *j*. The community's general rating of attribute *j*, or its popularity, is dubbed as the *community socio-technical indicator*, or β_j.

[Table 1: Parameters and Functions of an Application to Moderation]

A. Calculating the Community Socio Technical Indicator

Both the user socio-technical indicator $\alpha_{i,j}$, and, therefore, the community socio-technical indicator β_j, that is derived from the $\alpha_{i,j}$, are manipulated by the weighted ratings of attribute *j*. This application of the model assumes the use of a double-anchored rating scale, similar to Osgood's Semantic Differential Scale from -5 to +5. Ratings are weighted with user status in relation to an attribute, such that users with a higher status for a given attribute have more effect on valuing an attribute than have users with lower status. Various methods of determining ratings, initially setting user weightings for these ratings, and of combining weightings and ratings, simulate various characteristics of representative systems. For example, where all weightings are set to equal value (e.g. $\alpha_{i,j} =1$) represents equal valued rating system. Additionally, equally valuing all ratings (e.g. $r_{i,j}=1$) simulates a 'one man, one vote' system[4]. Otherwise, in an initially hieratical system, administrators or moderators could be assigned higher ratings than non-privileged users. Variable ratings may be collected through a user interfaced polling system associated with individual posts or, alternatively, defined on a community level.

The actual formula used in this application of the conceptual framework is to weight the rankings with user socio-technical indicators through multiplication. This requires that $\alpha_{i,j}\geq 1$, as any product where this is not the case would distort the average rating data by reducing it. In such a situation, a user's status would be reduced by including zero, or near zero, terms in the devisor of the average calculation, thus counter-intuitively implying that status is reduced by a contribution that encourages many ratings from low status users. It should be noted that deducing alternative formulas to the ones provided herein are possible extensions to research; a simple addition formula, for instance, would measure the popularity of an attribute's measure, rather than its mean rating. Indeed, there are six steps in the model where formulae are used and each of these is an opportunity to develop finer distinctions of flexible and representatively-moderated virtual communities.

The mean weighted rating, $\bar{r}$, is divided by the measure of the attribute so as to provide the ratio of average weighted weighting per occurrence of the attribute, or a scalar $m_{i,j}$ which indicates the general weighted rating of each single occurrence in *a* - that is, the measure of opinion per single occurrence. The harmonic average of $m_{i,j}$, for all occurrences of *j* and over all users, provides an average community weighted rating of a single generalised occurrence in *a* or, more simply, the community socio-technical indicator β_j. This value can be used as a recommender system, so as to automatically compute hypothetical ratings for posts and, also, to alter user socio-technical indicators.

B. Manipulating the User Socio-Technical Indicator

User socio-technical indicators must not only be sensitive to changes in a user's processes or contributions, but must also be sensitive to evolution in community norms, in terms of both the quality and the quantity of attributes that they represent. With respect to quality, we are concerned with changes in both the direction and the magnitude of user indicators and community indicators. Direction indicates whether a community approves or disapproves of an attribute; Magnitude indicates the extent of the approval or disapproval. Since β_j represents the average rating for an attribute, the measure of the direction of an attribute can be extracted from it. Simply, the community can be said to approve of an attribute *j* if $\beta_j > 0$, or to disapprove of it if $\beta_j < 0$. If $\beta_j =0$, however, then the ratings balance out and no clear consensus can be deduced from the community as to this regard. The value of β_j can be used to set a 'sign bit' which indicates the direction of the attribute. For the purpose of applicability to further formulae, the sign bit is represented as the scalar *s*, which can assume any of the values shown in Table 2. The extent of the direction of the community can also be determined from the community socio-technical indicator β_j, as it is simply the absolute value of β_j.

[Table 2: Sign Bit Values]

Since a user is an individual within the collective of the community, their contributions are valued with regards to the norms of the community. On a superficial level, this implies that a user's socio-technical indicator $\alpha_{i,j}$ must be related in some fashion to a user's mean weighted-rating $m_{i,j}$, to the community's generalised opinion β_j (both in terms of direction and magnitude). One formula for achieving this relationship is to alter $\alpha_{i,j}$ with regards to the ratio of a user's weighted-rating for each occurrence in *a* to the community's weighted-rating for each occurrence in a generalised *a*, or, more precisely, the scalar $f = (m_{i,j} / \beta_j)$. However, this formula considers only the value of the single generalised occurrence of an attribute, and it does not take into account the value of the entire contribution or process, which may consist of multiple occurrences. That is, the formula measures value whilst ignoring quantity. Thus, in measuring the value of an entire contribution, it is necessary to apply the value of the unitary occurrence to each occurrence within the contribution. In order to maintain a controlled system, this value can be included with respect to the community's average of occurrences, $\bar{a}_j$. Additionally, the direction of the attribute should be considered: If the community approves of the

[4] In such a scenario, an alternative to the 'mean weighted rating' formula, which is presented in the conceptual framework, is needed. Otherwise, outcomes will always be equal to 1.

attribute, then the user's socio-technical indicator should be increase by f; alternatively, if the community disapproves of the attribute, then the user's socio-technical indicator should decrease by f. This provides us with the more appropriate value:

$$f = \frac{m_{i,j}}{\beta_j} \times \frac{a_{i,j}}{\overline{a_j}} \times s$$

The simplified recursive definition for manipulating user *i*'s socio-technical indicator for an attribute *j* is $\alpha_{i,j[k+1]} = (f_{i,j} + \alpha_{i,j[k]})$, where k is simply an ordinal recurrence index. Since direction is multiplied into the formula, this allows us the intuitive option of simply summing all of the indicators of a user in order to calculate a representative user status. Negatively construed (i.e. where f<0) attributes will provide a decrease in status and positively construed attributes (i.e. where f>0) will provide an increase. If the community has not reached a consensus as to the value of the attribute, then the quantity which modify the indicator equates to zero (e.g. f=0), and the user status is not changed. Given f, such a definition provides for four mutually-exclusive scenarios, presented in Table 3.

[Table 3: Exhaustive scenarios for causes and effects on user status]

Perhaps, the outcomes in Table 3 are best understood through the adoption of two intuitively valued attributes, say 'profanity' and 'length of post'. For simplicity, in scenario A and C, where the community disapproves of the attribute, we shall consider that attribute to be 'profanity'. In scenarios B and D, where the community approves of the attribute, we shall consider that attribute to be 'length of post' – that is, the community approves of posts of an ideal length. In case A, the average rating for a contribution is negative and it can be inferred that the community does not approve of the post, with regards to profanity; hypothetically, the post might contain many occurrences of profanity and it has a negative rating in order to reflect this. The calculation of post quality (i.e. $m_{i,j}/\beta_j$) would result in a positive scalar as, at least on an analytic level, the user is conforming to community rating for profanity. Yet, since the norm for this attribute is one of disapproval, the sign bit reverses the rating to a negative scalar. Similarly, in case C, the community opinion is negative, but the user's post is rated positively. This is, given a negative rating in the quality calculation because the user's rating differs from that of the communities. Yet since the community's rating for the attribute is one of disapproval, the rating is reversed so as to have a positive effect on user status. Considering the attribute of 'post length', of which the community generally approves, a user who writes short messages receives a reduced status, such as in Scenario B. Conversely, a user who writes longer messages, such as in a Scenario D, receives a positive increment to their status. It should be noted that, although it is more intuitive to consider the table in terms of two attributes, it is equally valid and applicable in terms of a single attribute. For instance, Scenarios B and D could also represent a community which approves of profanity. The outcomes are verified by comparing the contribution rating $m_{i,j}$ with the effect on user i's status: user status should increase in contributions for which the community approves, and decrease in contributions for which the community disapproves. The attractiveness of the formula is that it is natural and intuitively appealing, whilst considering quality, in both direction and magnitude, and quantity.

C. Detecting Bias through a Context Effect

Further, the model is capable of identifying bias within the community. The quality ratio, $m_{i,j}/\beta_j$, makes differences between contribution ratings and general ratings explicit, for any single occurrence of a given attribute j. Through such a ratio, discreprencies between posts and community norms, or a *context effect*, can be easily identified. For instance, a user who is consistently rated poorly, due to a personal dislike of the user within the community, would consistently achieve lower ratings per attribute. Similarly, users who are personally preferred would consistently achieve higher ratings. Furthermore, the ratio can be used to measure the context effect of an attribute's degree. That is, although the scope of an attribute may be generalised, specific variations in the individual occurrences can be identified. For example, an occurrence of the attribute 'profanity' may be considered as being extremely offensive in one community, while the same occurrence may be considered as relatively insignificant in another. Hence, the Socio-Technical Indicator Model allows for the implementations of mechanisms to manage bias within a community.

VI. EXTENDED APPLICATIONS

The Socio-Technical Indicator Model lends itself to multiple extended applications, two of which are detailed in Table 4. A brief discussion of each application is provided below.

[Table 4: Parameters and Functions of Two Extended Applications]

In application to bio-conservation, the model is populated by species, with each species producing and/or consuming resources that affect their population. For any single resource, *j*, each species, *i…n,* produces a given amount of the resource, or $a_{i,j}$. For instance, if that resource is honey, bees might produce some quantity of honey ($a_{i,j}$ >0), while bears may not produce any ($a_{i,j}$ =0). Other species may have use for that resource, as bears may consume bees' honey, and the quantity of a resource that each member of a particular species uses is represented by $r_{i,j}$. The total amount of a resource that a species will consume is proportionate to both the size of the species (i.e. $\alpha_{i,j}$) and the need of individuals within the species for a resource (i.e. $r_{i,j}$), or $fA = \alpha r$. The total amount of a resource consumed by all other species, or the sum of all fA for all species, is fB. The amount of $a_{i,j}$ that remains after it has been partially or entirely consumed by members of other species is represented by fC. The amount of resources that remain in the environment, across the production of all species, is represented by a scalar fD, or the sum of all remaining resources. A negative scalar indicates that there exists a larger need for resources than there are resources available, whereas a positive scalar signifies that there exists more resource than there is need for that resource. The amount of a resource that the species produces in the future is viewed in relation to the amount of that resource available in their direct and indirect environment and to their need for that resource. The amount of self-produced resources that remain, or fC, being within the immediate environment of the individual, would also impact their future production. Additionally, the model can accommodate an awareness constant, which indicates how aware each species is of other species within its environment that consume that resource.

Within the context of a financial application, the model provides for alterations in the wealth of merchants in a competitive market. A merchant *i* produces a product with an attribute *j*, such as size or weight. Other merchants in the market value the product, and this value is combined with their wealth in order to provide a scalar indicating an amount that each merchant is willing to spend on the product in order to purchase it. This scalar, fA can reasonably be considered a Hysteresis function. In terms of the Socio-Technical Indicator Meta Model, the combination of these fA values, for each merchant, provides the *direct* market value of the product, or fB – that is, the total wealth that could be provided by the direct customers of merchant *i*'s product. The ratio of total wealth to the number of occurrences, or fC, provides the direct value of each occurrence. The *indirect* market value of the product is provided through the harmonic mean of all fC values, exclusive of the direct market value for merchant *i*. Hence, the profit of merchant *i*, within the context of attribute *j,* is the cost of production (i.e. *C*) subtracted from the total value of all the occurrences of an attribute - that is the sum of the direct and indirect value of the product, multiplied by the number of occurrences of the attribute.

VII. Conclusion

A Socio-Technical Indicator Model has been presented that operationalises, for multiple community-specific attributes, socio-technical indicators of characteristics that are valued by the community and that are responsive to the user collective. User responsiveness and monitoring of community values, is achieved through the community socio-technical indicators and individual user socio-technical indicators being derived as functions of basic parameters of on-going typical community communication processes. The basic parameters that have been identified can be chosen to represent fundamental characteristics of integrated feedback systems, and functions of those parameters can be flexibly chosen to simulate interactive processes that modify the community socio-technical indicators that monitor on-going valued states of these systems. Thus the model can simply describe a variety of complex, integrated feedback systems with multiple attributes and with structures as varied as bio-diversity, financial, and virtual community systems.

In particular, an illustrative application of the model has been detailed –one that can provide for on-line communities with evolving and self-regulating moderation mechanisms. The introduction of such mechanisms allows for the development of more representative systems than those implemented in current computer-mediated communication technologies. Indeed, computer-mediated communication technologies, have typically evolved in a cross-dichotomous manner, such that technical constructs of the technology have evolved independently from the social environment of the communities they serve. Hence, technical mechanisms of virtual community, such as moderation, have generally not been directly impacted by the community processes they moderate and, instead, have depended upon the external agency of community members to sensitize their operation within the static socio-technical environment of the community. Attempts to influence moderation by externally sensitizing the technology, as well as attempts to increase the representativeness of moderation, have been shown to restrict the flexibility of the community by inhibiting its evolution. In contrast, this detailed application of the model uniquely provides technical definitions of community values and attitudes, and allows for users to collectively monitor and control their communities in ways that promote the emergence of these values and attitudes.

The Socio-Technical Indicator Model simulates emergent valued characteristics of integrated multi-attributed communities. An illustrative application detailed here allows for more sensitive, representative and flexible systems of moderation for virtual communities. Such an application is an important milestone in the development of e-democracy, as it allows the democratic process to be accurately extended to virtual communities.

References

[1] Barry P.,Dekel U., Moraveji N., Weisz J. (2004). Increasing contribution in online communities using alternative displays of community activity levels. CHI 2004, April 24-29, 2004.

[2] Blanchard, A. L. and Markus, M. L. (2002). Sense of virtual community - Maintaining the experience of belonging. Proceedings of the 35th Hawaii International Conference on System Sciences, IEEE Computer Society, Volume 8.

[3] Cosley, D., Frankowski, D., Kiesler, S., Terveen, L., Riedl, J. and CommunityLab (2005). How oversight improves member maintained communities. Proceedings of the ACM Conference on Human Factors in Computing Systems, CHI 2005, Portland, OR.

[4] Farrand, Max (1937). The Records of the Federal Convention of 1787. Rev. ed. Vol. 2. New Haven and London: Yale University Press.

[5] Greening, D. R. (1989). Experiences With Cooperative Moderation of a Usenet Newsgroup. Proceedings of the 1989 ACM/IEEE Workshop on Applied Computing.
[6] Kelly, Sung, *et al*. (2002). Designing for Improved Social Responsibility, User Participation and Content in On-Line Communities. CHI Volume 1, Issue 1. ACM Press: New York.
[7] Kollock, P., Smith, M. (1996). Managing the Virtual Commons: Cooperation and Conflict in Computer Communities Pp. 109-128 in Herring, S. (ed.). Computer-Mediated Communication: Linguistic, Social, and Cross-Cultural Perspectives. Amsterdam: John Benjamins.
[8] Lampe, C., Resnick, P. (2004). Slash(dot) and Burn: Distributed Moderation in a Large Online Conversation Space. Proceedings of ACM Computer Human Interaction Conference, Vienna Austria.
[9] andfield, K. (2001). NetNews Moderator's Handbook. Retrieved March 23rd, 2005, from: http://www.landfield.com/usenet/moderators/handbook/
[10] Li, H. (2004). Virtual Community Studies: A Literature Review, Synthesis and Research Agenda. Proceedings of the Americas Conference on Information Systems, New York, New York, August 2004, pp. 2608-2715.
[11] Ludford, P.J., Cosley, D., Frankowski, D., & Terveen, L. (2004). Think Different: Increasing Online Community Participation Using Uniqueness and Group Dissimilarity. In *Proceedings of CHI 2004*, Vienna, Austria, pp. 631-638.
[12] Mabry, E. (1996). Frames and Flames: The structure of argumentative messages on the 'net. In Sudweeks, F., McLaughlin, M. and Rafaeli, S. (eds). Network and Netplay: Virtual Groups on the Internet. Cambridge, MA: AAAI/MIT Press.
[13] Nonnecke, B., Preece, J. (2000). Persistence and Lurkers in Discussion Lists: A Pilot Study. Retrieved May 29th, 2005, from: http://csdl.computer.org/comp/proceedings/hicss/2000/0493/03/04933031.pdf
[14] phpBB (n/d). phpBB 2.0 Full Guide. Retrieved March 27th, 2005, from: www.uscgaparents.org/phpBB2/fullguide.pdf
[15] inaldi, A.H. (1998). The Net: User Guidelines and Netiquette. Retrieved March 23rd, 2005 from: http://www.fau.edu/netiquette/net/.
[16] Whittaker, S., L. Terveen, W. Hill, & L. Cherny (1998): The Dynamics of Mass Interaction. In CSCW 98, Seattle, Washington, USA. ACM, pp. 257-264.
[17] Zakon, R. (1997). Request for Comments: 2235 (RFC2235). Network Working Group.

TABLE I
PARAMETERS AND FUNCTIONS OF AN APPLICATION TO MODERATION

	Parameters	Descriptor	Functions	Descriptor	Formulea
System parameters	i	User	$f_{A\,i,j}$	Weighted rating	αr
	j	Valued attribute	$f_{B\,i,j}$	Average community value of contribution from user *i*	$\bar{r}_{a\,i,j} = \frac{\sum_{i=1 \ldots i-1}^{i+1 \ldots n} \alpha_{i,j} r_{i,j}}{n-1}$
Internal parameters	α_i	Status of user *i*	$f_{C\,i,j}$	Average community value per occuence of contribution	$m_{i,j} = \frac{\bar{r}_{a\,i,j}}{a_{i,j}}$
	a	Number of occurences of attribute	$f_{D\,i,j}$	Popularity of attribute	$\beta_j = HM_i(m_{i,j})$
	$r_{i,j}$	Rating of attribute	$f_{E\,i,j}$	Change in status	$f = \frac{m_{i,j}}{\beta_j} \times \frac{a_{i,j}}{\bar{a}_j} \times s$

TABLE II
SIGN BIT VALUES

Type	$\beta_j \neq 0$ (Consensus Deduced)		$\beta_j = 0$ (Consensus Not Deduced)
Range	$\beta_j < 0$	$\beta_j > 0$	$\beta_j = 0$
Scalar s	$\beta_j / \lvert \beta_j \rvert = -1$	$\beta_j / \lvert \beta_j \rvert = 1$	$\beta_j = 0$

TABLE III
EXHAUSTIVE SCENARIOS FOR CAUSES AND EFFECTS ON USER STATUS

Scenario	$m_{i,j}$	β_j	$(m_{i,j} \div \beta_j)$	$f = \frac{m_{i,j}}{\beta_j} \times \frac{a_{i,j}}{\bar{a}_j} \times s$	Effect on alpha
A	-	-	+	-	←
B	-	+	-	-	←
C	+	-	-	+	→
D	+	+	+	+	→

World Academy of Science, Engineering and Technology
Vol:2 2007-02-21

TABLE IV
PARAMETERS AND FUNCTIONS OF TWO EXTENDED APPLICATIONS

Model		Marketing model		Bio-conservation model	
		Descriptor	Formulea	Descriptor	Formulea
System parameters	i	Merchant	-	Species (e.g. woodpecker, snake, squirel)	-
	j	Atribute of a product	-	Resource related to population growth/decrease	-
Internal parameters	α_i	Wealth of merchant i	-	Population size of species *i*	-
	a	Number of occurences of an attribute within a product	-	Amount of Resource j produced by specieces	-
	$r_{i,j}$	Value of product *j* to user *i*	-	Individual requirement of species *i*'s members for resource *j*	*Preset constant*
Functions	$f_{A i,j}$	Amount i is willing to pay because of this property	$\frac{\alpha}{\sqrt{2\pi}}\int_{-\infty}^{r} e^{-\frac{r^2}{2}} dr$	Amount of a_{ij} consumed (by a single species external to *i*)	αr
	$f_{B\ i,j}$	Value of aij from coistomers of merchant *i* , exposed to aij	$\sum_{i=1 \ldots i-1}^{i+1 \ldots n} \alpha_{i,j} r_{i,j}$	Amount of a_{ij} consumend by all species external to *i*	$\sum_{i=1 \ldots i-1}^{i+1 \ldots n} \alpha_{i,j} r_{i,j}$
	$f_{C i,j}$	Value of unit attribute based on customers of merchant-exposed users	$\frac{f_{B\ i,j}}{a_{i,j}}$	Amount of i's a_{ij} production left for the provider i	$a_{i,j} - f_{C i,j}$
	$f_{D i,j}$	Average indirect market value of attribute	$HM_{i=1 \ldots i-1}^{i+1 \ldots n}(f_{C\ i,j})$	Resource j available to all species (when f_D>=0)	$\sum_{i=1}^{n} f_{C\ i,j}$
	$f_{E\ i,j}$	Total profit of *a* to merchant *i*	$a_{i,j}(f_D + f_C - C)$	Total production perceived as being avalable for species *i*	$\frac{f_D + f_C}{r}$

International Science Index 2, 2007 waset.org/publications/10721