User Population and User Contributions to Virtual Publics: A Systems Model

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ABSTRACT

This paper provides a comprehensive review of empirical research into user contributions to computer-mediated discourse in public cyber-spaces, referred to here as virtual publics. This review is used to build a systems model of such discourse. The major components of the model are i) critical mass, ii) social loafing, and iii) the collective impact of individual cognitive constraints on the processing of group messages. By drawing these three components into a single model it becomes possible to describe the shape of a "user-contributions/user-population function" after controlling for context.

Virtual publics can be created with the support of various technologies including email, newsgroups, web-based bulletin boards etc. Traditionally the choice of technology platform and the way it is used has largely depended on arbitrary factors. This paper suggests that choices of this nature can be based on knowledge about required segmentation points for discourse as they relate to a particular type of technology. This is because the "user-contributions/user-population function" will map differently to different classes of technology. Similarly the different classes of technologies used to enable virtual publics will each have different stress zones at which users will experience information overload resulting from computer mediated discourse.

Keywords

Computer Mediated Communication, Information Overload, Virtual Communities, Discourse Structures, Group Communication, Coordination Theory, Systems Theory.

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INTRODUCTION

We are spending more and more of our time communicating via computers through technologies such as email, web-based bulletin boards, etc. Numerous authors have noted that such technologies allow user interaction on a larger scale than was previously possible via face-to-face group meetings [13, 51]. One outcome of this trend is that collaborative media systems now exist, where the audience is the primary source of media content as well as its primary receiver [38,39]. Users of such systems often gain a sense that they are part of a social gathering or in some cases a community. Consequently, Steven Jones [18] coined the term cybersociety to refer collectively to the new forms of social interactions and the complex social systems, such as virtual communities, that have emerged from the wide-scale use of these technologies. The term cybersociety does not refer to the technology used to support CMC or to CMC itself. Rather it refers to the social interactions and connections that are supported by the various computer networks that have now merged to become the Internet.

The social interactions, which form the basis of cybersociety, occur via a variety of public settings and private communication channels. These public cyber-places we have termed 'virtual publics'. More formally, virtual publics are symbolically delineated computer mediated spaces, whose existence is relatively transparent and open, that allow groups of individuals to attend and contribute to a similar set of computer-mediated interpersonal interactions. The need for this term exists for a number of reasons. First, not all virtual publics have associated virtual communities [16, 17]. Second, it is important that a term exists that distinguishes between cybersociety and its public spaces. Finally, despite the differences in the technological and social aspects of virtual publics, their similarities require a collective label.

A virtual public's symbolically delimitated space must be 'relatively transparent and open' to distinguish it from private group mediated space. For example, a password protected corporate employees-only discussion board would not constitute a virtual public. This is because the public would probably not know about its existence (i.e. it is not transparent) nor would they be able to use it (i.e. it is closed rather than open).

The term "*virtual public user-population*" refers to the individuals that engage themselves in a virtual public's symbolically delineated space. For example, the user-population of a web based bulletin board virtual public would be those individuals that over a period of time surfed to examine the web-based discussion. It would not include those that only irregularly examined the discourse material in another setting that did not allow them to engage in discourse. Similarly to be considered part of an email based virtual public's user population would require list subscription. Therefore, we would not consider a non-subscribed spammer a part of the user-population. Clearly, not all cases of membership are clear-cut, however the vast majority of cases can be categorized.

With an understanding of user-population, it is possible to distinguish between participants that are 'lurkers' and those that are 'contributors'. Lurkers are members of a virtual public's user-population that do not engage in public discourse. Contributors are members of a user-population that over a period engage in public discourse.

We proceed by examining the literature that relates to virtual public user-contributions and user-population. This will allow for the presentation of a new model of user-contribution and user-population that synthesizes the current findings. With the help of this model, an examination will be made of the connection between a virtual public's technology-base, user-population, and user-contributions. It will then be possible to present a systems-model of group communication in virtual publics.

2.0 VIRTUAL PUBLIC DISCOURSE, USER CONTRIBUTIONS & USER POPULATION

The literature review below is divided into three sections. The first deals with initiating sustainable interactive discourse in virtual publics. The second with the relationship between user-population growth and user-contributions, once discourse is firmly established. The third examines various constraints to the expansion of discourse in individual virtual publics.

2.1 Initiating Sustainable Interactive Discourse

The question being addressed here is, how many users are needed for contribution levels to be high enough to sustain interactive discourse in a virtual public?

The interactive-communication in this paper refers to the concept defined by Rafaeli [36] and expanded upon by Rafaeli and Sudweeks [35]. Interactivity is not a characteristic of the medium. It is the extent to which messages in a sequence relate to each other, and especially the extent to which later messages recount the relatedness of earlier messages. This definition of interactivity recognizes four levels of communication: broadcast or one-way communication, two-way communication, reactive communication, and fully interactive communication. Two-way communication is present as soon as messages flow bilaterally. Reactive communication is when in addition to a bilateral exchanges later messages refer to earlier ones. Fully interactive communication requires that later messages in any sequence take into account not just messages that preceded them, but also the manner in which previous messages were reactive. The literature is insistent that interactive communication is a necessary part of computer mediated group discourse. This is because true conversations require interactive-communication [12, 34, 35, 52].

Hiltz and Turoff [13] proposed a "critical mass hypothesis" for sustainable interactive-CMC. Their theory resulted from the observations of early computer conferencing systems. They noted that conferences with less than 8 to 12 active users would after a short while fail to produce enough new material to justify users continued use of the system. They also observed that some of the users of these small conferences simply migrated to larger and more active conferences.

Palme [32] expands upon the work of Hiltz and Turoff's and argues that "for the exchange of experience," as opposed to task-focused communication, 20 to 50 active participants are required. Palme also proposes a 'communication response function' to explain the group size threshold for sustainable-CMC. His function works as follows: If we assume, that the probability for each group participant to reply to a message is 0.05 then at least 21 participants are required for a message to generate on average one reply. Thus, with fewer than 21 participants the chain reaction is sub-critical. If the group size is larger than 21 participants then each message will, on average generate more than one message, and we get a sustained chain reaction. Of course, the real figures are not always exactly 0.05 and 21, but Palme [32] proposes that the principle still applies.

To date no detailed empirical research has been conducted into the critical mass required to sustain interactive group-CMC in various contexts[1]. However, some evidence in support of critical mass theory does exist from the study of corporate GroupWare. Whittaker [49] found that large Lotus Databases used for the purposes of archiving and communicating, were more likely to generate further conversations and archiving than small ones.

[1] We are currently conducting large-scale field research into the boundaries of virtual public discourse. We are specifically examining the constraints to discourse via Listserv and the Usenet.

A number of other authors have also produced critical mass theories of reciprocal behavior [10]. Markus [27] proposed a critical mass theory for the adoption of interactive media, which has been extended to examine its predictions in regards to group-CMC [39]. The extension suggests that contributions to collaborative media will grow exponentially with group size. Likewise, a logical extension of Palme's 'communication response function' is an exponential growth in contributions with group size. However, as shown in the next two sections, the relationship between user-population and user-contributions cannot be articulated by a simple function.

2.2 User Contributions to Ongoing Virtual Public Discourse

The few empirical studies that have explored the relationship between user-contributions and user-populations in ongoing computer mediated group discussions have consistently found that a small minority of participants post a large proportion of messages.

Smith [45] examined the relationship between user-contributions and a growing user-population in his study of 'The Well', at that time a commercial Bulletin Board System (BBS). Smith found that 1% of the 7000 person user-population, or seventy people, generated 50% of all the WELL's postings and that this was in spite of an influx of new users over the study period. Further, Rafaeli and LaRose [39] in their study of North American BBS' did not find a linear relationship between group size and contributions.

Rojo and Ragsdale [42,43] found that 82% of the user population of academic email forums never contributed. That is users never asked for information, provided information, asked or answered complex questions, made short comments, or made an elaborate comment.

The results of a study by Whittaker et al. [51] of 2.15 million Usenet postings from 500 newsgroups over a 6-month period suggest a non-linear relationship between user-population and user-contributions. This is because they found "massive participation inequalities between different people in a given newsgroup' (p.262). For example, 27% of messages to the newsgroups studied were contributed by individuals who only ever posted once.

The above findings are in line with Thorn and Connolly's [47] discretionary database theory, in which they propose that the contribution rate will drop as user-population grows. This, they argued, is because users can enjoy the benefits of everybody else's contributions without having to incur the cost of contributing personally. For the same reason they also propose that contribution rates will drop when there are greater contribution costs, lower values of information to participants, and greater asymmetries in information. Ironically, Thorn and Connolly found evidence to support their theory in all areas except group-size. This is because they compared groups with four or eight individuals, numbers that are probably below critical mass.

An alternative explanation for non-linear relationship between user-population and user-contributions where discourse is established is Latane's Social Impacts Theory [22]. Latane's theory holds that social influence is a multiplicative function of the strength, immediacy, and number of people affecting any given individual. Therefore, the amount of effort expended on group tasks should decrease as an inverse power function of the number of people in the group. Latane's theory has been used to explain 'social loafing' [23], which is the reduction in individual exertions in group situations, in an extremely wide range of contexts [24]. Latane [23] suggests three possible explanations for social loafing although his model is not dependent on their validity.

- Attribution and equity – individuals make faulty attributions about group member's behavior and reduce effort in an attempt to maintain equitable division of labor.
- Sub-optimal goal setting – individuals lower their personal goals in social settings.
- Lessening of contingency between input and output - individuals can hide in crowds or fail to measure accurately their own input.

In the case of virtual publics, a reduction in user-contributions with increases in user-population could be viewed as social loafing.

Smith [45] offers another explanation of different levels of user-contributions. He notes that one of the most common and accepted tenets in the literature on cooperation is that "the larger the group, the less it will further its common interests" [31]. He also lists a number of reasons why individuals may *free ride*, that is fail to contribute because of a belief that the efforts of others will suffice. First, as the group becomes larger, the costs of an individual's decision to free ride are spread over a greater number of people. Second, if an individual's action does not appreciably affect others, the temptation to free ride increases. Third, it is often the case that as group size increases anonymity becomes increasingly possible and an individual can free ride without others noticing their actions. Fourth, it becomes more difficult to coordinate the activities of members in order to discourage free riding. Smith goes on to argue that this logic does not hold for the Usenet because he does not consider lurking to be equivalent to free riding. Instead, he discusses anti-social behavior such as being off-topic, posting huge articles, or violating decorum, all of which may or may not constitute free riding.

2.3 Constraints to Discourse Expansion

Numerous authors have noted that CMC technologies enable user interaction on a larger-scale than was previously possible via face-to-face group meeting[2] [37,38,51]. This in turn has resulted in an emphasis on the way CMC removes constraints to group interaction. For example, Rheingold [40] suggested that CMC would result in a new flowering of "community" because individuals can now truly shape their own communities by free choice of *virtual-association*.

The popular notion of the limitlessness of cyberspace has lead to the view that the major constraint to the 'growth' of a virtual public is the ability to "maintain a sense of community" [11]. There are a number of problems with this perspective. First, it is not clear exactly what constitutes "a sense of community," nor whether this sense is crucial. Second, as will be demonstrated in section three and four, a focus on system-structure is probably a more fruitful line of research. Finally, the drastic reduction in technological and physical constraints to group-communication do not result in the removal of fundamental limits to human cognitive processing.

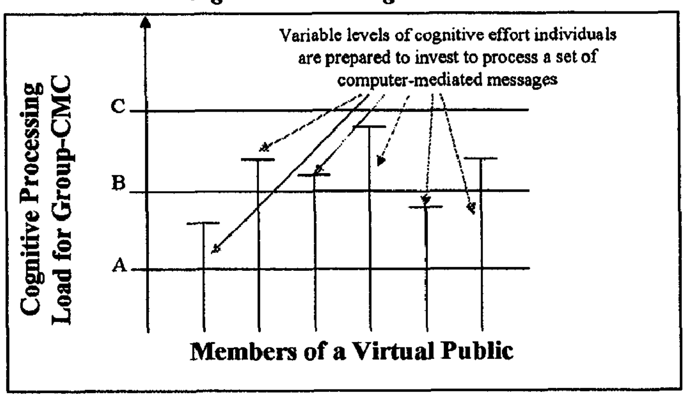
2.3.1 *Individual and Group Cognitive Processing Limits*

Nearly all regular users of the Internet have at times experienced what is commonly referred to as "information overload", that acute sensation of being swamped by unwanted information [44]. This occurs because the degree to which information technologies can effectively control or aid CMC is limited by the finite capacity of human cognition. Humans can only undertake a finite amount of information-processing tasks during a given period of time [20, 28]. Such constraints are inherent to any biological mechanism for perceiving and processing information. In other words, humans can think about almost anything, but they cannot deal with everything at once. There is also a limit to the aggregate amount of interactive group communication that humans can manage [2]. Therefore, it is not surprising to find extensive evidence in the natural world of the relationship between biological and behavioral measures of cognitive processing capacity[3], such as group size in primates [5].

It follows that the inability of members of a virtual public to process effectively certain message patterns will result in limitations to the possible forms of sustainable group-CMC. That is, beyond a particular communication processing load, the behavioral stress zones encountered will make group communication unsustainable. Communication load being the processing effort required to deal with a set of communications.

Diagram 1 shows the relationship between individual and group processing limits. Three cognitive processing loads for group-CMC, A, B and C will be examined. At cognitive load A all individuals are willing or able to process group messages. At cognitive processing load B two individuals will not be able to effectively process group messages and at load C none of the individuals displayed will be able to effectively process group messages. In other words, the cognitive processing abilities of groups are not simply the sum of its individual's cognitive processing capacities. Consequently, certain patterns of interactive group-CMC cannot be sustained if the required processing effort (communication load) is higher than the maximum amount individuals can or are prepared to invest.

Diagram 1. Individual & Group Cognitive Processing Limits



Communication-processing load relates to a number of message system characteristics. Users generally have to make more of an effort to reply coherently to a thread [25] than to a single message. Therefore, higher interactivity correlates with higher communication-processing load. Similarly, a dense pattern of messages (high frequency of postings) will require quicker and more sustained processing by group members. Therefore, message density will also covary with communication-processing load. It is also likely that an increase in 'interactional coherence', not compensated for by a useable persistent record, will also increase communication-processing load [12]. For example, disrupted turn adjacency may require increased user effort to track sequential exchanges. Disrupted turn adjacency is caused by the fact CMC-systems, such as email lists, transmit messages in the order they are received without regard to what they are in response to. Thus in group-CMC a message may be separated from a previous message it is responding to by another

[2] Dunbar [5] suggests that there is an upper limit of about four individuals to face-to-face interactive conversations.

[3] Biological approximations to cognitive processing capacity can be based on the neocortex ratio. The neocortex ratio is based on the volume of the neocortex to the volume of the rest of the brain. It can also be adjusted for the ratio of brain volume to body mass [5].

message, or lags in message transmission may even result in reversed sequencing.

Above it was concluded that: *'beyond a particular communication processing load the stress zones encountered will make group communication unsustainable.'* This suggests that it is also possible to explore group cognitive processing limits empirically if we can identify the behavioral stress zones. This is because only a limited range of actions are possible to an individual once group communication results in information overload [14]. Actions include:

1) Making an increased effort for a short period [2].
2) Learning new information management techniques to reduce the information overload. This is mostly relevant for inexperienced users of a particular technology[4] [12, 14].
3) Failing to respond or attend to certain messages, thereby lowering the growth in communication load. The result being a change in the relationship between user-population and contributions.
4) Producing simpler responses. This will result in a change in the form group communication takes.
5) Storing inputs and responding to them as time permits. Again changing the group communication pattern.
6) Ending participation in the group communication. This appears to be one of the most common responses [6].

The above list can be reduced to two options for a population of experienced users. The first option is simply to end participation. The second option is to change communicative behavior so that it becomes manageable. Therefore, from a systemic exploration of the communication patterns of many large-scale virtual publics it should be possible to identify the stress zones caused by cognitive processing limits.

2.3.2 *Group Cognitive Processing Limits and CMC*

Research into 'information overload' has mostly focused on individual information management rather than how it influences group communication. Examples of topics explored include:

- The use of aggregated data under time pressure as a method of coping with information [46];
- Information overload and improved information retrieval [21, 29, 30]
- The personal information management of email [50].
- Information overload and health issues, e.g. memory loss and urban stress [42].

The importance of such issues has lead Berghel [3] to argue that information overload represents the biggest challenge facing users of the Internet in the year 2000.

Despite its importance only a handful of authors have noted the impact of information overload on group communication. Hiltz and Turoff [13] noted that "technology governs the size of the group that can effectively communicate." Kerr and Hiltz [19] suggested that what Palme [32] later referred to as the 'communication response function' (see section 2.1 above for an explanation) could lead to an unmanageable information explosion. Hiltz and Turoff [14] were the first to explore systematically group-CMC and information overload. They highlighted the potential relationship between technology type and information overload by arguing that tools for structuring communication could help individuals avoid information overload.

Alstyne and Brynjolfsson [1] suggested that cognitive processing limits would result in "cyber-balkanization," because individuals will choose to interact with individuals with similar interests and opinions. Hiltz and Wellman [15] noted the negative impact information overload has on virtual classrooms based around asynchronous CMC. Chen, Nunamaker, Orwig, and Titkova [4] examined a visualization technique as a way to reduce information overload resulting from collaborative computing. Most recently, Turoff et al. [48] produced a conceptual model of how collaborative discourse structures could be used to reduce the communication-processing load resulting from group-CMC.

To date no attempt has been made to systematically identify group-CMC patterns that produce information overload. This is probably due to the lack of a detailed theoretical approach and methodology for exploring the issue until now [17]. It is also probably because, except for Van Alstyne and Brynjolfsson, the focus of research in the area has been on the behavior of individuals using closed systems (e.g. Group Support Systems[5] and Asynchronous Learning Networks) rather than virtual publics. The significance of this point will be expanded upon in sections 4 and 5, on modeling group-CMC.

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[4] Hiltz and Turoff [14] found that feelings of overload would peek at intermediate levels of CMC use when communication volume has built up but users have not had time to develop screening skills.

[5] Group support systems researchers have explored the impact of group size on CMC based task performance. However, these researchers have considered group sizes of 12 to 18 members large [7].

3.0 USER-POPULATION CONTRIBUTION MODEL

Section 2 examined the literature that relates to virtual public user-contributions and user-population. This section presents a new diagrammatic model of user-contribution and user-population that synthesizes the current findings. It may be interesting to note that the model resembles Rogers' [41] s-shaped Diffusion of Innovation Curve, although in the case of this curve the inflection points are identified.

Diagram 2. User-Population/User-Contribution Model

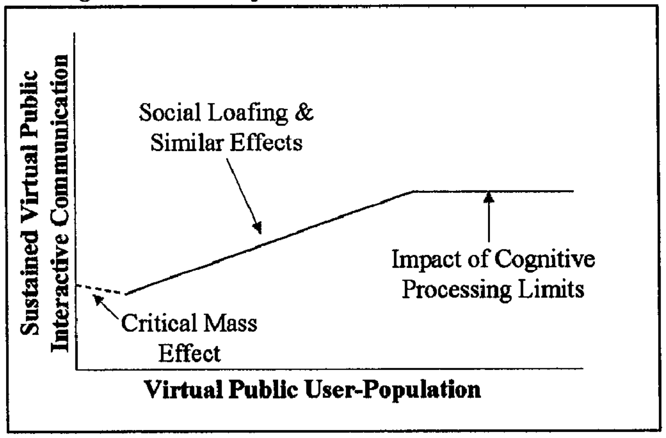

Diagram 2 shows the typical relationship between interactive communication and user-population if contextual factors are held constant. By contextual factors we are referring to factors such as individual differences and events that alter communication patterns (e.g. an election or a flame war, etc). The claim here is not that user-behavior in virtual publics has to follow the curve presented here. Rather, that:

1) Critical mass will have to be reached for interactive group-communication to be sustained. How this point is reached will probably vary widely hence the faded line until the critical mass point.
2) An increase in a virtual public's user-population will not typically result in an equal increase in interactive communication if discourse is already ongoing.
3) Individual cognitive-processing limits produce a constraint to discourse expansion even if the user population continues to grow.

Until now these three components have not been linked together. This is despite the significance of the described relationships for constructing a useful research program into the relationship between user-contributions, user populations and technology.

4.0 TECHNOLOGICAL BASE, USER CONTRIBUTIONS, & USER POPULATION

In section 2.3 a number of papers were listed that noted the relationship between CMC-technologies and the point at which CMC leads to information overload. This section will discuss how this relationship can be modeled via field research.

From the discussion above, we can extract two points that are crucial to understanding the role of technology in interactive group-CMC. First, for all CMC technologies a critical mass of user contributions will be required to sustain discourse. Second, there is a relationship between how a CMC-technology structures communication, and the point at which group CMC results in information overload. This is because technology type is correlated with message systems characteristics, which in turn relate to communication-processing load. Diagram 3 is extrapolated from these points.

Diagram 3. Virtual Public Technology & Communication-Load

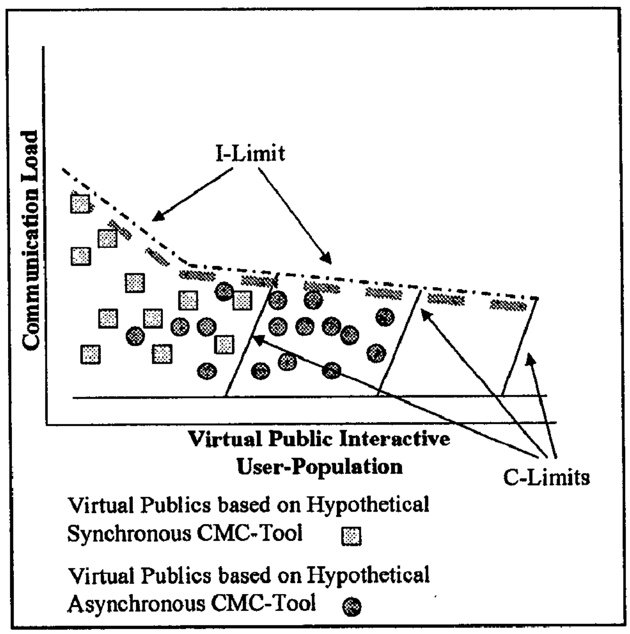

Diagram 3 summarizes the proposed behavioral constraints on the growth of discourse in two classes of hypothetical virtual publics. The hypothetical virtual publics are based on either a synchronous or an asynchronous technology. The I-Limit represents the maximum sustainable communication load; the C-Limits the durability and storability of messages used to communicate via a class of virtual public. The line parallel to the x-axis represents critical mass. The lines in the diagram represent stress zones or boundaries where behavioral limitations become severe. They do not represent rigid, deterministic, instantaneous halt lines. This is because even though virtual publics can be used in a variety of unpredictable ways, sustained interactive group discourse will be constrained by critical mass and cognitive processing limits. In other words technology can both enable and constrain its users but it does not determine use.

The approach used to construct diagram 3 can be used to better comprehend the impact of various technologies on the structure of discourse in virtual publics. For example, lets assume that the synchronous tool in diagram 3 is IRC and the asynchronous email. A relatively synchronous CMC-technology such as IRC may be able to reach a higher communication load than an email list because of the speed at which users in a channel window can reply to the comments of other users. Therefore the I-limit is higher above the IRC plots. However, IRC channels may not be able to reach the same user-population as a function of message density as an email list where users can store messages and take time to structure a response. As a result one would expect IRC to have a different C-limit to email.

Diagram 3 also suggests a research program. This is because it implies that the stress zones caused by overloaded interactive communication can be identified empirically by the large-scale mapping of active participation in different types of virtual publics. A similar technique has been used by archaeologists to study the limits to conventional human settlement growth [8, 16, 17]. Quentin Jones [16] labeled the application of such a methodology to CMC 'cyber-archaeology', as it focuses on the material artifacts of cyberspace. The authors are currently conducting such research into the boundaries of email and Usenet based virtual publics.

It should also be noted here that the model outlined in diagram 3 does not say anything about the content of virtual public discourse within the boundaries imposed by technology, or who will use one virtual public as opposed to another. To say something meaningful about the content of discourse, social theory and a focus on context are required [17]. While it may be the case that different types of computer mediated discourse may have different stress boundaries (e.g. empathetic as opposed to technical, moderated or facilitated as opposed to unmoderated), this is an empirical question whose answer would not impact on the overall validity of the model outlined. In other words the model does not attempt to explain individual variations in the discourse patterns observed. Rather the model focuses on stress-boundaries as these provide the key link between technology and discourse structures.

5.0 A MODEL OF GROUP COMMUNICATION IN VIRTUAL PUBLICS

The preceding sections showed how virtual public discourse can be understood as the output of a variety of interlocking variables. In other words, virtual public discourse can be considered the output of complex social system. To understand the impact of the expansion of any part of a complex system on the system as a whole, an examination of its internal constraints is required [26]. This is because the constraints will invariably produce interlocking nonlinear feedback loops [9]. A "Feedback loop" is the environment around any decision point in a system. The decision leads to a course of action that changes the state of the surrounding system and gives rise to new information on which future decisions are based.

Diagram 4 highlights the nonlinear feedback loop discussed in previous sections although not labeled as such. The diagram can be understood in the following way. An increase in the membership of a virtual public will probably result in an increase in virtual public communication. However, because of cognitive processing limits it will not be possible to expand virtual public communication indefinitely (i.e. an internal constraint). Once virtual public communication becomes unmanageable or incoherent, it is likely that there will be an impact on virtual public population size or growth. That is, there will be a nonlinear feedback.

Diagram 4. Virtual Public Nonlinear Feedback Loop

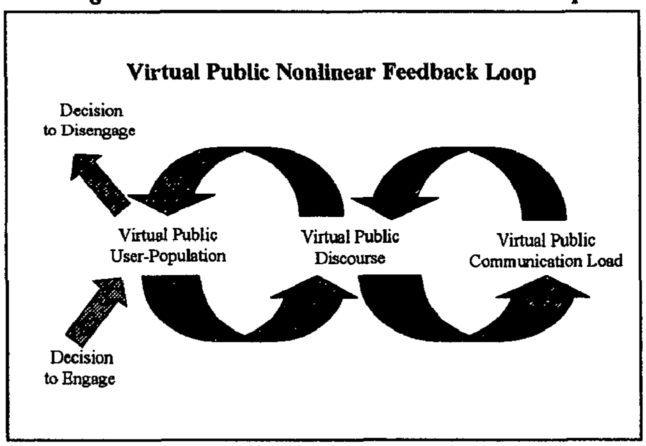

Diagram 4 while recognizing the need to populate a virtual public does not directly address this issue. This is because user-population can be considered an external/ecological constraint to virtual public growth [17]. An examination of external constraints to virtual public growth, while important, is beyond the scope of this paper and is not necessary for understanding virtual public nonlinear feedback loops. This paper has instead focused on the description of internal constraints to virtual public discourse.

The above model, and its sub-components, (the user-population/user-contributions model, and the technology communication-load model) describes dependencies between activities, and examines prerequisites and constraints to communication. As such, it can be considered a type of co-ordination theory [26].

The systems approach to modeling virtual public discourse leads to a variety of conclusions. Perhaps most importantly it shows how the expandability of virtual public discourse will depend on the purpose of a virtual public, the discourse structure, and its technology base. This is because these factors will all affect the point at which information overload becomes an issue. In other words the systems approach leads to the rejection of the notion that technology has removed the constraints to the exponential growth of group discourse [11, 32]. Therefore if discourse expansion is desired but no longer possible because of information overload, some form of segmentation via the creation of new related virtual publics is required. Further, it follows that the appropriate point for segmentation of a virtual public will depend on its purpose, its discourse structure and its technology base.

CONCLUSION

This paper examined virtual publics by exploring the relationship between their user-population, their interactive user-contributions, and their technology base. There are a number of reasons why understanding how these three factors inter-relate is important. Three reasons standout in particular, these are:

1) Managers of virtual publics often want to increase user-population and contributions to coherent interactive group communication. The reasons for this vary depending on the purpose of the virtual public. In the case of e-commerce, Hagel and Armstrong [11] argue that it is advantageous for corporations to "grow" user contributions and size in relevant virtual publics[6]. This is because they can influence online purchase decisions, increase customer feedback, and encourage members to make repeated contact with relevant cyber-places such as corporate web sites. Online self-help groups may also find it advantageous to expand user-contributions and size. This is because larger online self-help groups tend to produce more unique ideas and make people feel more comfortable about communicating [33].
2) To comprehend communication via virtual publics we must come to better understanding of the factors that influence online contributions and allegiances.
3) The technological changes that brought about cybersociety have not only raised new questions but have also provided new ways of researching and hopefully answering some of the older ones.

[6] Hagel and Armstrong use the term "virtual community," however this term does not distinguish between community, place and interaction [16,17]. To avoid potential confusion we have used the term virtual public.

The paper presented a model of "interactive-communication in virtual-spaces" that incorporates aspects of information and coordination theory. The model generates various hypotheses and a coherent *research program*. Hypotheses generated include the following:

- The collective impact of individual *cognitive processing-limits* constrains the number of individuals that can be involved in interactive-communication in individual virtual spaces.
- The maximum number of individuals that can actively participate in coherent interactive-communication in individual virtual spaces relates to both the technology type and the cognitive effort that participants are prepared to devote to message processing.
- The stress zones caused by overloaded interactive communication can be identified empirically by the large-scale mapping of active participation in different types of virtual places.

This paper outlines how the collection and analysis of field data can be used to address various scaling issues, which are of great importance to the designers and managers of virtual teams and communities, as well as e-commerce strategists. Further, the models provided suggest that conducting empirical research as outlined will significantly increase our understanding of the relationship between media and user communication in general.

REFERENCES

1. Alstyne, M.v., and Brynjolfsson, E. (1996). Electronic communities: Global village or cyberbalkans? Online, March 1999: www.mit.edu/people/marshall/papers/CyberBalkans.pdf.
2. Berger, C. R., Knowlton, S. W. et al. The hierarchy principle in strategic communication. *Communication Theory* 6, 2, 1996, 111-142.
3. Berghel, H. Cyberspace 2000: Dealing with information overload. *Commun. ACM* 40, 2, 1997, 19-24.
4. Chen, H., Nunamker J. Jr., et al. Information visualization for collaborative computing. *Computer* 31, 8, 1998, 75-82.
5. Dunbar, R., *Grooming, gossip and the evolution of language.* Harvard University Press, Cambridge Mass, 1996.
6. Finholt, T. and Sproull, L. S. Electronic groups at work. *Organization Science* 1,1, 1990, 41-64.
7. Fjermestad, J. and Hiltz, S. R. Experimental studies of group decision support systems: An assessment of variables studied and methodology, in *Proceedings of the 30th Hawaii International Conference on System Sciences* (Hawaii 1997), IEEE, 45-65.

8. Fletcher, R. J. *The limits of settlement growth: A theoretical outline*, Cambridge University Press, Sydney, 1995.

9. Forrester, J. *Urban Dynamics*. The M.I.T. Press. Cambridge, Mass., 1969.

10. Fulk, J., Flanagin, A. J. et al. Connective and communal public goods in interactive communication systems. *Communication Theory* 6,1, 1996, 60-87.

11. Hagel, J. and Armstrong, A. *Net gain: expanding markets through virtual communities.* Harvard Business School Press, Boston, Mass., 1997.

12. Herring, S. C. Interactional coherence in CMC, in *Proceedings of the 32nd Hawaii International Conference on System Sciences,* (Hawaii 1999), IEEE Press.

13. Hiltz, S. R. and Turoff, M. *The network nation: Human communication via computer.* Addison-Wesley Publishing Company, Inc., London, 1978.

14. Hiltz, S. R. and Turoff, M. Structuring computer-mediated communication systems to avoid information overload. *Commun. ACM* 28,7, 1985.

15. Hiltz, S. R. and Wellman, B. Asynchronous learning networks as a virtual classroom. *Commun. ACM* 40, 9, 1997, 44-49.

16. Jones, Q. Virtual-communities, virtual-settlements & cyber-archaeology: A theoretical outline. *Journal of Computer Mediated Communication,* 3, 3, 1997. Online: www.ascusc.org/jcmc/vol3/issue3/jones.html

17. Jones, Q. and Rafaeli, S. What do virtual 'Tells' tell? Placing cybersociety research into a hierarchy of social explanation. In *Proceedings of the 33rd Hawaii International Conference on System Sciences,* (Hawaii 2000), IEEE Press.

18. Jones, S. G. Cybersociety: Computer-mediated communication and community. In *Understanding Community in the Information Age.* Sage, Thousand Oaks, CA, 1995, 10-35.

19. Kerr, E. B. and Hiltz, S. R. *Computer-mediated communications systems: Status and evolution.* Academic Press, New York, 1982.

20. Kramer, A. and Spinks, J. Capacity views of human information processing. In *Handbook of Cognitive Psychophysiology: Central and autonomic nervous system approaches.* Eds. J. R. Jennings and M. G. H. Coles, John Wiley & Sons Ltd, 1991

21. Krulwich, B. and Burkey, C. The InfoFinder Agent: learning user interests through heuristic phrase extraction. *IEEE Intelligent Systems* 12, 5, 1997.

22. Latane, B. The psychology of social impact. *American Psychologist,* 36,4, 1981, 357-360.

23. Latane, B., Wiliams, K. et al. Many hands make light work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology* 37,6,1979, 822-832.

24. Latane, B., Nowak, A., et. al. Measuring emergent social phenomena: Dynamism, polarization, and clustering as order parameters of social systems. *Behavioral Science,* 39, 1994, 1-24.

25. Lewis, D. D. and Knowles, K. A. Threading electronic mail: A preliminary study. *Information Processing and Management* 33,2, 1997, 209-217.

26. Malone, T. W. and Crowston, K. The interdiscplinary study of coordination. *ACM Computing Surveys* 26, 1994, 87-119.

27. Markus, M. L. Toward a critical mass theory of interactive media. *Communication Research* 14, 1987, 491-511.

28. Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity to process information. *Psychological Review* 63, 1956, 81-97.

29. Montebello, M. Information overload - An IR problem? In *Proceedings of the 21st annual International ACM SIGIR conference on Research and development in information retrieval,* ACM. Press. 1998.

30. O'Leary, D. E. The Internet, Intranets, and the AI Renaissance. *Computer,* 30, 1997, 71-78.

31. Olson, M. J. *The Logic of Collective Acton.* Harvard University Press, Cambridge Mass, 1965.

32. Palme, J. *Electronic Mail.* Artech House Inc., Norwood Mass, 1995.

33. Phillips, W. A comparison of online, e-mail, and in-person self-help groups using adult children of alcoholics as a model. Online: Rider University. www.rider.edu/users/suler/psycyber/acoa.html, 1996.

34. Rafaeli, S. The electronic bulletin board: A computer driven mass medium. *Computers and the Social Sciences,* 2, 1986, 123-36.

35. Rafaeli, S. and Sudweeks, F., Networked interactivity. *Journal of Computer Mediated Communication* 2, 4, 1997, Online, www.ascusc.org/jcmc/vol2/issue4/rafaeli_sudweeks.html

36. Rafaeli, S. Interactivity: From new media to communication. *Sage Annual Review of Communication Research: Advancing Communication Science.* Sage, Beverly Hills, 16, 1988, 110-134.

37. Rafaeli, S. Interacting with media: Para-social interaction and real interaction. *Information and behavior.* Eds. B. D. Ruben and L. Lievrouw, Transaction Publishers. 3, 1990, 125-181.

38. Rafaeli, S. and LaRose, R. Audience activity and participation in electronic bulletin boards: A national survey. In *Proceedings of the Annual meeting of the International Communication Association,* Chicago, IL, 1991.

39. Rafaeli, S. and LaRose, R. J. Electronic bulletin boards and 'public goods' explanations of

collaborative mass media. *Communication Research* 20,2, 1993, 277-297.

40. Rheingold, H. *The virtual community: Homesteading on the electronic frontier*. Addison-Wesley, Reading, Mass, 1993.

41. Rogers, E. M. *Diffusion of innovations*. Free Press, New York, 1983.

42. Rojo, A. and Ragsdale, R. G. Participation in electronic forums: Implications for the design. *Telematics and Informatics,* 14, 1, 1997, 83-96.

43. Rojo, A. and Ragsdale, R. G. A process perspective on participation in scholarly electronic forums. *Science Communication,* 18, 4, 1997, 320-341.

44. Shenk, D. *Data smog - Surviving the information glut*. HarperCollins, New York, 1997.

45. Smith, M., Voices from the Well: The logic of the virtual commons. *Sociology*, UCLA, 1992.

46. Speier, C., Using aggregated data under time pressure: A mechanism for coping with information overload. In *Proceedings of the 31st Hawaii International Conference on System Sciences,* (Hawaii 1998), IEEE Press.

47. Thorn, B. K. and Connolly, T., Discretionary databases: A theory and some experimental findings. *Communication Research* 14, 1987, 512-528.

48. Turoff, M., Hiltz, S. R. et al., Collaborative discourse structures in computer mediated group communication. *Proceedings of the 32nd Hawaii International Conference on System Sciences,* (Hawaii 1999), IEEE Press.

49. Whittaker, S., Talking to strangers: An evaluation of the factors affecting electronic collaboration. In *Proceedings of CSCW '96*, (Cambridge Mass 1996), ACM Press.

50. Whittaker, S. and Sidner, Email overload: Exploring personal information management of email. *Proceedings of CHI96*, ACM Press, 1996.

51. Whittaker, S., L. Terveen, et al., The dynamics of mass interaction. *Proceedings of CSCW 98*, (Seattle 1998), ACM Press.

52. Zack, M., H., Interactivity and communication mode choice in ongoing management groups. *Information Systems Research,* 4, 3, 1993, 207-239.