PATTERNS OF PROGRAMMERS' USE OF COMPUTER-MEDIATED COMMUNICATION SYSTEMS

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ABSTRACT

Communication behavior of programmers plays an essential role in success of software development. Computer-mediated communication (CMC) system, such as e-mail, or the World Wide Web (WWW), have substantial implications for coordinating work of programmers. Yet, no studies have dealt systematically with CMC behaviors of programmers. Drawing upon theories in organizational studies, information science, computer-mediated communication and software engineering, this research examines what programmers accomplish through CMC systems.

Data were gathered from survey questionnaires mailed to 730 programmers, who are members of the Association of Computing Machinery (ACM) and are involved in a variety of programming work. Based on factor analysis, the study found that programmers use CMC systems (1) to achieve progress in work-related tasks (i.e., task-related purposes), (2) to satisfy their social and emotional needs (i.e., socio-emotional purposes), and (3) to explore for information (i.e., exploring purposes).

The findings of this research extend an insight into important patterns for which programmers use CMC systems. This insight has advanced theories of computer-mediated communication in the context of computer programmers. Also, practitioners, especially in software development, may use the results as guidelines in fostering a firm's feasible network policy that fits with what their programming staff accomplish through computer-mediated communication.

INTRODUCTION

The goal of this research is to extend our understanding of computer-mediated communication (CMC) behavior of programmers. Similar to other professionals, programmers must possess certain skills besides their programming abilities, one of which is communication expertise. Empirical work has shown the importance of programmers' communication behavior. At Microsoft, for example, programmers often exchange feedback with colleagues regarding their work (Cusumano & Smith, 1997). Formal communication, such as meetings with clients, improves the quality of software products (Kraut & Streeter, 1995). Also, informal communication such as interaction among programmers at a vending machine appears to have a significant impact on programming quality (Fowler, 1999; Weinberg, 1998).

In addition to the basic principle that programmers should have open communication with other people, software engineers have developed rigorous guidelines to improve programming performance. These guidelines offer instructions by which programmers learn how to integrate programming expertise with communication efforts in a way that maximizes their productivity (Humphrey, 1997; Yourdon, 1996, 1999). Code reviews, for example, are software engineering techniques that encourage programmers to share and review code with peers and correct flaws which may be detected during the reviews (Yourdon, 1996).

Despite the importance of computer-mediated communication behavior of programmers, no empirical studies have dealt exclusively with this topic. The current study explores one important, yet largely unknown aspect: the manner in which programmers are engaged in computer-mediated communication.

COMPUTER-MEDIATED COMMUNICATION SYSTEMS

Computer-mediated communication (CMC) systems are defined in this study as programmers' perceptions of a collection of tools that facilitate human communication via computers and electronic communication networks. Because of the evolution of technology, a great number of CMC systems offer various features such as information searching or information filtering. Although these features are not central to the communication, they extend the utilitarian functions of

CMC systems. It must be clear that the focus of this research is on CMC systems as perceived by programmers to primarily facilitate human communication. The systems that do not support human communication are therefore excluded from the study. Specifically, the systems that mainly (1) support the software development process (e.g., CASE tools), (2) promote the management of projects, or (3) provide access to database systems are not part of the family of CMC systems and therefore excluded from this study. In addition, neither voice mail nor facsimiles are included because a large number of users do not perceive the communication via these two channels as computer-mediated (Rice & Steinfield, 1994). Thus, the instances of CMC systems investigated in this research include computer conferencing systems (e.g., e-mail or visual conferences), Internet-based communication (e.g., Internet relay chat (IRC), Internet phone, or the WWW), group support systems, groupware (e.g., Lotus Notes) and the systems that support communication via e-mail, newsgroups and/or listserves.

CMC SYSTEM USAGE AND PROGRAMMERS

The study's main focus is to examine what programmers accomplish through the use of CMC systems. This focus is consistent with Rice's (1980, p. 238) critical remark that "… it would be fruitful to determine just what it is that people do when they interact via computer." Findings from previous studies note that people are engaged in computer-mediated communication for at least two key purposes: to attain progress in work-related tasks and to satisfy social and emotional needs.

Researchers and practitioners in organisational communication have acknowledged the use of CMC systems to achieve progress or completion in work-related tasks. Sawyer and Guinan (1994, 1998) examined how computer-mediated communication would affect intra-group conflict-solving process and control management among teams of software developers. "By focusing [on] the work product, and not [on] each other, the product becomes less attached to any one person: it is shared by the team" (Sawyer & Guinan, 1994, p.82). With help from CMC systems, eliciting program requirements from users appears to be more effective than doing the same with no help (Liou & Nunamaker, 1993). Retrieval features in major CMC systems can also reduce clerical errors in code reviews (Johnson, 1998).

In addition to task-related benefits, the use of CMC systems can accommodate the social and emotional needs of programmers. This type of use has been ascertained in various investigations, although only a few have been conducted in the programmer context. For example, workers used e-mail not only to handle work assignments, but also to stay in touch with friends or family, or to meet people with the same interests (Rice & Steinfield, 1994). With a speedy transmission of distributed computing technology and algorithms that facilitate network security, programmers can complete any financial transaction (i.e., purchase a plane ticket or buy stock) over the Internet as well as locate almost any information of interest. They can also be entertained by a variety of information offered through CMC systems, or download numerous kinds of information for their own pleasure (Mehta & Plaza, 1997).

Besides the two major purposes (i.e., task-related and socio-emotional), evidence from the literature suggest that programmers may use CMC systems for other purposes. For instance, Rice and Steinfield (1994) identified the surveillance purposes for using e-mail in an organisational setting. Other writers comment that organisational members may use communication to explore innovative ideas from the environment and, perhaps, share the knowledge with colleagues (Heath, 1994; Farace, et al., 1977).

METHODOLOGY

The current research employs a self-administered mail survey to gather data from 780 actual programmers who are members of the Association of Computing Machinery (ACM). In the typical worst case of a possible 30% response rate commonly known in the survey literature, the sample size of 780 is likely to yield more than 230 survey respondents, the number of which is acceptable to provide a statistically significant finding (Babbie, 1992). It is important to note that a set of fifty programmers from the ACM list were drawn to participate in a pilot study, leaving the total of 730 programmers for the actual survey.

Questionnaire development

The study's questionnaire was developed based upon (1) an extensive review of literature on computer-mediated communication, software engineering, and organisational research and (2) the researcher's interviews with programmers. From the literature review, questionnaire scales associated with various purposes for using CMC systems. The subsequent interviews with actual programmers allowed for appropriate adjustments to the scales so that the questionnaire could be clear and understandable to programmers.

When the first draft was ready, the questionnaire was pre-tested with a group of programmers, survey scholars and information system researchers. Based on feedback from these pretest participants, changes to the questionnaire items were made to reduce ambiguous wording, poor transition among sections in the questionnaire, or unclear explanation, thereby enhancing the clarity and comprehensibility of the instrument. After the pretest, the questionnaire was pilot-tested with fifty programmers drawn from the ACM list. Statistical techniques were applied to the pilot test so as to assess the questionnaire's reliability and validity and to modify it based on the results. Results from the pilot test confirmed the acceptable quality of the questionnaire, thereby yielding reliable and valid data necessary to satisfy the research's objectives.

Survey administration

One of the drawbacks in using a mail survey is a low response rate. Sometimes, it is so low that the final conclusion is improbable. The researcher has made an effort to draw as many responses as possible by following recommendations from survey researchers (Babbie, 1992; Dillman, 2000). The effort included (1) notifying subjects about the survey before they receive the questionnaire, (2) preparing all survey documents (e.g., a cover letter or a questionnaire) in the ways that motivate subjects to promptly and accurately respond to the survey and (3) implementing a three-step follow-up plan. Within a three month period of data collection, 438 programmers returned usable questionnaires. This amounts approximately to a 60% response rate. According to Babbie (1992), it is a good response rate.

About 40% of the subjects did not return the questionnaires. It may therefore pose bias between respondents and non-respondents. Using the trend projection approach (Hertman, et al., 1985; Smith, 1997), however, no bias was detected.

RESULTS

Respondent characteristics

Table 1 presents important characteristics of programmers who participated in this research. The highlights of these characteristics are as follows:

- The majority (88%) of participants are men. About half (56%) of the respondents hold their highest degree in computer science while other individuals are from adjacent fields: mathematics (13%), engineering (11%), management and business administration (6%), information science (4%) and physics (3%).

Table 1: Characteristics of Participating Programmers

Major Characteristics	Respondents N	(%)
Gender (N=431)		
Male	381	88
Female	50	12
Age (N=434)		
20-29 yrs.	18	4
30-39	134	31
40-49	166	38
50+	116	27
Highest Education (N=434)		
College degrees or some college work	118	27
Masters or some graduate work	273	63
Doctoral or higher	43	10
Major (N=429)		
Computer science	239	56
Mathematics	55	13
Engineering	49	11
Management or Business Administration	27	6
Information science	16	4
Physics	13	3
Others (e.g., Education, Music, etc.)	30	7
Number of hours per day doing programming work (N=429)		
1-3 hrs	127	30
3-6	118	27
6+	184	43
Work responsibility (N=432)		
Developing in-house systems	181	42
Developing packaged software	149	35
Installing packaged software in-house	17	4
Combination of the above three	23	5
Others (e.g., educational software)	62	14

- Considering that the sample was selected from regular members of the ACM who described themselves as programmers, it is not surprising that more than half of the respondents (63%) hold master degrees and about the same percentage (65%) are forty years old or higher. It seems that young programmers or those fresh from college are not ACM members as they may not yet realize the benefits of the memberships. Still, it is possible that selecting members of a professional association as research participants may bias the study.
- The research collected data from actual programmers, instead of from computer-related students. For at least six hours per day, a fair number of participants (43%) are engaged in programming work such as designing, testing, writing or maintaining computer software. Furthermore, responses to the questionnaire's "work responsibility" item seem to confirm that the participants are in charge of various types of programming projects, ranging from developing in-house software systems (42%) and building packaged software products (35%), to installing packaged software (4%). Also, they reported that they have been working as programmers for approximately eighteen years. These findings thus ensure that

the survey participants encompass professional programmers holding various actual programming responsibilities, not student programmers working on class assignments.

Patterns of CMC system usage

Thirty-five items reflecting various activities in which one may be engaged through the use of CMC systems were included in the questionnaire (see these items in Appendix A). To indicate how often subjects use CMC systems for these activities, they rated the items from never (0) to very often (4). An "other" item was added as subjects may use CMC systems for purposes not listed. However, only five programmers responded to the "other" item, two of whom used CMC systems for monitoring a stock market and the other three used them for miscellaneous activities. The responses to the "other" item were subsequently excluded from subsequent analysis.

To uncover the key purposes underlying what programmers accomplish through the use of CMC systems, the thirty-five items were factor-analyzed. Prior to the analysis, however, the items with marginal variance were excluded as they would not serve to differentiate among emerging factors (Comrey & Lee, 1992). An objective criterion of a standard deviation of less than one is used to determine which items should be dropped from the analysis. As a result, four of the 35 items were excluded. These four items are: enjoying provocative contents, acquiring non-computer knowledge, locating people with the same conditions and learning about social events.

Based on factor analysis with principle axis extraction and oblique rotation, three meaningful factors that underscore the major purposes for which programmers use CMC systems emerged. Table 2 displays the three purpose factors and the items that reflect on each purpose. Also included are weights of the items on the three factors. The three factors together explained about 42% of the variance among the purpose items. According to Table 2, Factor I accounted for 29.1% of the variance. Highest weights of the nine items on the first factor seem to reflect the "task-related" use of CMC systems. Factor II explained 8.3% of the variance. Four items loaded highest on this factor, indicating that programmers use CMC systems for "socio-emotional" benefits. The final factor, Factor III, accounted for 4.5% of the variance. Highest weights of the other four purpose items tend to suggest the "exploring" purpose for using CMC systems. Assessments of the factor structure (e.g., Kaiser-Meyer-Olkin (KMO) index, residual correlation analysis, and Bartlett's test of sphericity) suggest that the discovery of these three purposes behind programmers' use of CMC systems is conceptually parsimonious and methodologically sound.

CONCLUSIONS

Programmers' accomplishments through use of CMC systems

Upon the study's results, programmers appear to use CMC systems for three major purposes. They are task-related, socio-emotional and exploring. The first two purposes are commonly recognized in the literature. However, the recognition of the third purposes is relatively limited. Researchers and practitioners have known that communication serves in general as a means to (1) transfer information for individuals to achieve their work progress and (2) satisfy one's social and emotional needs. The study's findings of these two purposes may stress the essential combination of "work" and "play", particularly in the workplace environment; and therefore indicate that the use of CMC systems for socio-emotional purposes is as useful as the use to gain progress in work-related tasks.

The use of CMC systems for exploring purposes is noted by a few scholars (Choo, 1998; Farace, et al., 1977; Metroyer-Duran, 1993). These researchers have acknowledged exploring functions of computer-mediated communication as the transfer of knowledge or innovative information between an organisation and its environment. This piece of information may help an organisation to cope with changes, especially when the organisation's environment is undergoing dramatic shift. Given the dynamic and various changes in the software development environment, it is reasonable to argue that programmers conduct an exploration via CMC systems, perhaps, in search of software innovation and creative ideas (e.g., ready-to-use programming applets, or details of product upgrades) so as to survive the turbulent condition. Choo (1998) comments that the Internet--an instance of CMC systems—offers a unique channel through which technology-oriented industries such as software development firms could explore and benefit from various types of information.

Implications

Implications for existing theories in many fields may be derived from the study's findings. Regarding communication functions, the current study has confirmed the need to incorporate all three major purposes (i.e., task-related, socio-emotional and exploring) into research on computer-mediated communication. Much research has addressed the use of communication to achieve task-related benefits as well as to satisfy one's social and emotional needs. However, relatively little research has covered the purposes of exploring for information in one's environment. Overlooking one purpose may result in an incomplete understanding of communication functions.

Table 2: Factor Analysis Results: Purposes for Using CMC Systems

Purpose Items	Factors			
	I	II	III	
Factor I: "Task-Related"				
Discuss work information with co-workers	**.75**	.06	-.01	
Coordinate work with distant colleagues	**.52**	-.01	-.04	
Schedule meetings	**.65**	-.05	-.04	
Give or receive feedback on work assignments	**.74**	.04	.03	
Send confirmation to colleagues/clients	**.64**	.02	.01	
Discuss work with clients	**.54**	.04	.08	
Resolve work conflicts or disagreements	**.60**	.03	.07	
Transfer files	**.54**	.05	.31	
Keep track of what's happening in a company	**.53**	.10	.06	
Factor II: "Socio-Emotional"				
Fill free time	-.02	**.77**	-.02	
Greet people on social occasions (e.g., sending friends electronic cards)	.16	**.52**	.05	
Be entertained (e.g., electronic humor)	.02	**.68**	.02	
Take a break from work	-.02	**.78**	-.06	
Factor III: "Exploring"				
Check out new services/products	.03	-.04	**-.75**	
Stay up-to-date on computer or product upgrades	.02	.04	**-.73**	
Seek out alternatives to work problems	.05	.03	**-.62**	
Download information	.00	-.02	**-.83**	
Percent of Variance Explained	*29.1%*	*8.3%*	*4.5%*	*=41.9%*

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research has covered the purposes of exploring for information in one's environment. Overlooking one purpose may result in an incomplete understanding of communication functions.

In addition to theoretical implications, the findings also have practical utility. Not only did the study confirm that programmers use CMC systems to attain work progress and to satisfy their own social and emotional needs, it also empirically noted that the programmers are engaged in exploration via CMC systems. These exploratory activities include downloading information over the Internet, staying up-to-date on computer-related issues, checking out new services and seeking out alternatives to work problems.

Limitations

Inferences from this research are limited by two major factors. First, the demographics of the participants appear to temper the study's generalizability of results to the programmer population in general. The programmers who participated in this study are dominantly male, between 30-49 years of age and with at least a college degree. This consequently limits the generalization of the study, despite the random sample of about 700 members, the high percentage of survey returns and the respondents' various programming responsibilities.

The second limitation is more methodological. This is a cross-sectional study. Further, the phenomenon under study (i.e., CMC system usage) is dynamically changing due to rapid development of computer technology. Hence, the analyses and the conclusions in this manuscript present only a snapshot of how programmers use CMC systems. Additionally, prior to this study, very little was known about programmers' computer-mediated communication behavior. The study's execution was therefore made based upon an exploratory approach. This is the main reason that the investigated patterns were neither hypothesized nor tested. Nevertheless, the study has ascertained the three purposes for which programmers use CMC systems. Future studies may thus test any specific hypothesis on their use of computer-mediated communication.

Appendix A

How often do you ***use CMC systems of all kinds to accomplish*** *the following activities? Think of the activities that you complete by using CMC systems. Please circle the appropriate number.*

I use CMC systems generally in order to:	Never	Rarely	Some times	Often	Very Often	Not applicable
Distribute or discuss work information with co-workers (e.g., design alternatives).....................	0	1	2	3	4	8
Check out the weather..	0	1	2	3	4	8
Place a purchase order...	0	1	2	3	4	8
Look up job or promotion openings.....................	0	1	2	3	4	8
Coordinate programming work with distant colleagues..	0	1	2	3	4	8
Check out new services/products (e.g., updated software)...	0	1	2	3	4	8
Seek help for non-work problems (e.g., how to fix a floor)..	0	1	2	3	4	8
Schedule meetings with colleagues/clients...........	0	1	2	3	4	8
Update an address book...	0	1	2	3	4	8
Give or receive feedback on work assignments.....	0	1	2	3	4	8
Fill free time...	0	1	2	3	4	8
Complete a work assignment from outside the office………………………………………..	0	1	2	3	4	8
Greet people on social occasions (e.g., birthday)..	0	1	2	3	4	8
Send confirmation to colleagues or clients...........	0	1	2	3	4	8
Stay up-to-date on or learn about computer technology or product upgrades.........................	0	1	2	3	4	8
Discuss work information with clients.................	0	1	2	3	4	8
Be entertained (e.g., electronic humor or computer games)..	0	1	2	3	4	8
Stay updated on an area of interest (e.g., a hobby)..	0	1	2	3	4	8
Enjoy provocative contents..................................	0	1	2	3	4	8
Keep in touch with friends or family members......	0	1	2	3	4	8
Seek out alternatives to work problems (e.g., a better algorithm or reusable code).....................	0	1	2	3	4	8

I use CMC systems generally in order to:	Never	Rarely	Some times	Often	Very Often	Not applicable
Learn about or participate in social events (e.g., protest a new law, time to enjoy fall foliage)......	0	1	2	3	4	8
Locate human experts for help with work (e.g., programming) problems....................................	0	1	2	3	4	8
Find people of the same conditions or same social interests (e.g., antique-car lovers)..................	0	1	2	3	4	8
Resolve work conflicts or disagreements..............	0	1	2	3	4	8
Check out sports events (e.g., golf tournament results or scores of last night's games)..............	0	1	2	3	4	8
Take a break from work..	0	1	2	3	4	8
Learn non-computer knowledge (e.g., new way of recycling or health-related information)............	0	1	2	3	4	8
Create and maintain bookmarks............................	0	1	2	3	4	8
Transfer files to colleagues...................................	0	1	2	3	4	8
Keep track of what's happening in my company...	0	1	2	3	4	8
Hold a work conference with colleagues (or clients)..	0	1	2	3	4	8
Other *(please specify...)*	0	1	2	3	4	8

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