Methodology for Observing Decision Making and Collaboration in Multi-Dimensional Synthetic Work Environments

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Abstract

Literature increasingly includes documentation that new organizations with varying roles and tasks are being developed simultaneously with the development of new technology in short time frames. It is often difficult separating the streams of data related to task definition, organizational design, training needs, and systems during testing. Multi-focus, rapid prototyping of new organizations, roles and decision support technology in one complex, field-like context requires that researchers devise or adapt methods to capture useful information regarding the advantages of implementing new organizational structures and new technology. The focus of this paper is the development of a data collection method, which can be applied in a realistic, synthetic work environment where a number of factors (i.e., task, tools, environment) are being varied simultaneously. The resulting methodology is a hybrid of Breakdown Analysis, a method of usability analysis used in synchronous computer supported collaborative work (CSCW) systems development (Scrivener, et al, 1993) and Heuristic Evaluation, a method of usability analysis of individual computer interface designs from the human-computer interaction (HCI) research (Nielsen, 1994).

Introduction

The US Army Field Artillery warfighting environments are rapidly evolving from linear to non-linear operations. The Field Artillery requires organizations and weapons that are highly flexible and can be rapidly organized and postured to support a wide range of mission objectives. One solution is to combine streamlined battle staff organizations with information technology. At the core of the proposed organizational transformation are shared, common databases and secure, reliable, long range communications that support non-linear, distributed operations.

The Future Fires Command and Control (F2C2) Concept Experimentation Program 1 (CEP 1) established a test bed to address organization transformation by conducting soldier-supported experimentation which focused on combining streamlined battle staff organizations with information technology. The F2C2 system consisted of a Field Artillery Battalion Tactical Operations Center (FA BN TOC), an Effects Coordination Cell (ECC), a surrogate Future Fires Decision Support System (F2DSS), and a communications system. The focus of this paper is the development of a methodology for collecting and analyzing data regarding the interactions of the player-participants of the FA BN TOC with the F2DSS and the communications system.

The FA BN TOC is staffed by eight personnel who gather information, track the battle, assess risks, plan, direct, monitor the common operating picture (COP), and adapt to change based on their perceptions. Its organization includes command, operations, force protection, combat service support (CSS), and plans elements. The TOC is capable of continuous operations or autonomous operations, when sufficiently manned for 24-hour day operations.

The surrogate F2DSS design is based on the Army Battle Command System (ABCS) functionality. The purpose of the F2DSS is to create a system that will mimic the functionality of the ABCS currently in use, but improve on the user interface and the collaborative support the system offers, and to create a more flexible system than is currently available. The F2DSS is designed to prototype the technology we envision could be available for common use by 2005. The F2DSS was specifically designed to enhance the projected organizational design for 2005 which we are also testing. The F2DSS was made up of networked computers that shared a common database and could be used to display a COP. A Decision Aid Toolkit was installed on each workstation, where the operator could use the F2DSS to select the specific tools and information he needed to perform mission essential task. The F2DSS was created to enable maximum user control over the information flow and is sufficiently robust to permit easy use and rapid recovery from software problems.

Communication during testing was also facilitated by crew access units (CAUs), which provided intra- and inter-command post communications. A CAU was installed at each F2DSS workstation. The CAU simulated single channel ground and air(borne) radio systems (SINCGARS) tactical radios and vehicular intercoms used by the staff to plan, prepare, conduct, and assess operations. Each device was initialized to represent radio frequencies. The CAU allow the unit to organize its voice information flows. Two intra-vehicular nets were established 1) operations and intelligence, and 2) planning. Up to eight devices in the C2Vs could be assigned to either net.

Development of a Data Collection Methodology for the Test Bed Environment

The challenges to data collection included a number of factors being varied simultaneously, work that is increasingly cognitive as well as collaborative, and simultaneous technology development to support both individual and collaborative work. Our approach to data collection in a complex environment like the F2C2 testbed is based on an ecological perspective. Flach, Vincente, Tanabe, Monta, & Rasmussen (1998) reviewed approaches and made a case for an ecological or "use-centered approach" to systems engineering as the overarching approach. This perspective starts with a broader view of the system. While most approaches consider the technology or the user-technology coupling as the system, the ecological approach includes human and technology in the context of "a larger work or problem space" (Flach et al., p.297). This view regards the human or the team in the loop as an adaptive, meaning processing part of the system as opposed to an information processing system with limited capacity—a view that emphasizes designing systems to be manageable.

Rassmussen and Vincente (1989) coined the term "ecological interface design" to characterize the use-centered approach. "Ecology" is used as opposed to "environment" to emphasize the reciprocal dynamic among the technology, the user, and the work environment. The assumption is that the constraints or affordances of technology can only truly be understood if they are examined in relation to their impact on work in the situation in which they are to be used. Technology must be examined *in situ*, i.e., in the context in which it is used with a focus on determining how it effects the production of work.

In developing a methodology for collecting data that would implement the ecological perspective we naturally examined options for observation, though a review of systems development for ABCS revealed that survey technology had been used extensively (Grynovicki, personal communication, 2000). We were, however, concerned with the drawbacks of both, direct observation and self-reports. Observation of actual work processes, i.e., of the conversations during the processes, reveal problem areas, but avoids the use of post-action verbal protocols. One main drawback to observation, however, is that much of the interesting parts of an interaction are internal to the user and not available for direct observation (Crellin, et al., 1990).

In order to gain the strengths and avoid the weaknesses of both observation and self-report, we chose to implement an observational method called Breakdown Analysis (Scrivener, et al, 1993), and we used a self-report questionnaire designed as a written Heuristic Evaluation (Nielsen, 1994) to complement the observational data.

Breakdown Analysis avoids the self-report and reconstruction of events that are prone to bias. It is also specifically designed to analyze the use of software systems designed for two or more people. The idea behind analyzing breakdowns, as reported by Winograd and Flores (1986) is that a system is usable only if the user can work on tasks while remaining unaware of the system. If, during the execution of a task, the user becomes aware of the role that the system is playing in the effort to perform that task, the user's concentration "breaks down." Therefore, a system's usability can be evaluated through an examination of the breakdowns experienced while users attempt to use the system. The method also creates a framework to observe all breakdowns in task performance, not just those attributable to the software system. Because Breakdown Analysis reveals problems in individual task performance, collaboration, and technology usage, and even the adequacy of the testbed environment used, it was considered an ideal tool for collecting data during the F2C2 experiment. Breakdown Analysis is executed in three phases: 1) notation and classification of the breakdown (i.e., user-tool; user-user; user-task; user-environment); 2) determination of the probable cause for the breakdown (diagnosis); and 3) what to do to fix it (remedy).

Neilsen (1994) has characterized Heuristic Evaluation as of the main "discount usability methods." Heuristic Evaluation involves having a small group of evaluators examine an interface to judge its compliance with recognized principles (the heuristics) (Neilsen, 1994). Typically, the evaluators verbalize to an observer or write out their findings. In traditional user testing, the goal is to have the user discover problems while using the technology without further explanation by the designer or observer. In the F2C2 CEP 1, we adapted the Heuristic Evaluation content and administration. Our approach was to administer a questionnaire after the users had several days to investigate the technology in a work setting. The principles we assessed in the survey we designed were key factors that have emerged in the military setting and that are in line with use of a collaborative system. The factors were 1)did the technology support decision-making, 2) did the technology support situational awareness, 3) did the technology support meaningful information, and 4) did the technology support collaboration. We were particularly interested in whether the two methodologies would reveal the same or different types of problem areas in the software, and whether we could attribute some problems revealed in self-report to causes other than the software design by analyzing the Breakdown Analysis data.

Results

In our initial application of the hybrid methodology we identified potential strengths and weaknesses of the method. We were also able to provide specific recommendations about system design as well as organizational and task design. We found that the Breakdown Analysis as documented in the literature required more structure for our observers to make notes than was apparent in the literature's documentation of previous uses. We did find that "breakdowns" were actually fairly evident and easy to classify according to type. However, we did not establish inter-observer reliability in this first application. We did find that the two methods highlighted different types of software design problems. It also appeared that some design drawbacks were not memorable to the user as he was immersed in the task, and were overlooked once he was asked to give retrospective impressions. Recording the conversations indicating breakdown created a record of problems. More specifically, the reasons for the breakdowns in software use were more apparent when all the breakdown categories were examined. By this we mean that a user might report a software design problem that could really be attributed to misunderstanding the task, or to the organizational design.

Future Development

Using Breakdown Analysis in combination with the written Heuristic Evaluation provided us with the benefits of direct observation while minimizing the drawbacks. While Breakdown Analysis identifies, diagnoses, and suggests a remedy for usability problems, the written Heuristic Evaluation can also provide valuable insights with regards to the users' perceptions of how the system fits into the work process. Plans are underway to establish inter-observer reliability, to standardize the observation approach and analysis method for use in the next F2C2 experiment, to focus the approach on specific questions about system design such as how the system supports or does not support Situational Awareness.

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