Abstract

This paper reviews the concept of the Living Laboratory and the potential impact of this framework on research perspectives, the design and approach of computer-supported cooperative work (CSCW) systems, and application to specific domains such as emergency crisis management. The main purpose behind the present research is to inform the development of distributed collaborative technology prototypes from multiple perspectives. Given the scope and depth of the CSCW research paradigm, McNeese and colleagues put forth the Living Laboratory Framework to promote an interdisciplinary view of how computers can support cooperative work for complex, emergent situations. Research based on the Living Lab framework would provide understanding of the intentions, goals, values and beliefs that drive individual behavior in their related context, and likewise how intentions influence patterns of behavior in the context of teamwork. This paper demonstrates how the Living Laboratory framework can be applied to a complete research program, and how it aids in the development of envisioned designs of collaborative technology that can facilitate distributed cognition within real world contexts where teamwork involves various levels of complexity.

1 Introduction

The utilization of teamwork to handle ill-defined situations, put decisions into action, and solve complex problems is changing as the necessity to integrate information, technology, people, and practice increases significantly. The approaches that designers use to address the requisite level of integration for teamwork can vary to a large degree as a function of their previous training, expectations, biases, assumptions, and extent of effort. This paper attempts to understand the significance of this problem as it relates to design, and then to pose the Living Laboratory perspective as a framework to facilitate a comprehensive, integrative approach to the design of computer-supported cooperative work (CSCW) systems and describes its application to research conducted within the emergency crisis management and homeland security/defense domains. At the heart of our research is the desire to develop prototypes of distributed team communication and information technologies based on theoretical principles from situated cognition (Brown, Collins, & Moore, 1989; Greeno & Moore, 1993); distributed cognition (Cole & Engstrom, 1993; Hutchins, 1995); and cognitive systems (Hollnagel & Woods, 1983; Woods, Johannesen, Cook, & Sarter, 1994).

1.1 Significance

Within the broad perspective of computer-supported cooperative work, designers may take a number of different approaches to generate systems that produce some form of efficiency, effectiveness, or usefulness when it comes to performance. Indeed, what often emerges in the form of artifacts, interfaces, support, or tools can be the result of design processes/procedures that emphasize alternate and sometimes even conflicting positions. Much of our own work in CSCW has identified four distinct perspectives (i.e., technology-centric, data-centric, user-centric, and group-centric) in creating systems or designs to support cooperative work (McNeese, Zaff, & Brown, 1992).

Technology-centric views often reify the intuition of the designer as being correct. Thus, the designer utilizes technology without really knowing the needs, requirements, or constraints of the work setting. Designs are informed through the knowledge of what technology offers and treated as ends unto themselves. Multiple cases exist where designs have emerged because of the “quick rush” to market an innovative idea (e.g., the recent explosion of smart
phones and handheld devices). Once introduced, the user is expected to conform and learn the complexities of the design despite a device’s clumsy automation or automation surprises (Woods et al., 1994) that may be present. Clearly, this kind of design process results in systems that fail or induce user mistakes. For example, many large group display products in the 1980s were made possible with the introduction of certain kinds of technologies (e.g., gas-plasma displays; refer to McNeese & Brown, 1986). These displays were at one point put forth as solving many problems of increasing display size without sacrificing resolution. However, the display was not designed specifically for human use and could be subject to actually decreasing human performance because of tradeoffs that actually incurred with the technology. Unfortunately, usability approaches may be “too little, too late” as they are often applied as surface-level analyses only after the “real design” has been conceptualized. Post hoc usability is better than nothing but is not optimal.

One of the first alternatives to techno-centric approaches was data-centric designs. In this approach to design, laboratory experiments are conducted for a given hypothesis for a set of phenomena related to group work (e.g., experiments in social psychology, team performance, or social cognition). Data is collected in controlled research facilities employing sophisticated experimental designs and then analyzed using statistical techniques. Based on the results of these studies, a researcher can generalize findings beyond the locally-controlled study. Such generalizations may suggest that specific design concepts or features would improve performance in a given manner. The problem herein is that findings tend to be over-generalized, suggested designs are unproven, and studies often ignore contextual or ecological variables that influence results. This view highlights the role of theory and abstraction in design and certainly can be informative from top-down considerations.

Alternatively, a more viable approach is user-centered design. Here, the user is placed in a role alongside the designer to assist with usability. A designer is thus informed as to the users’ needs, how they are constrained, and what forms of cognitive processes are used to interpret work. A user-centric design approach acknowledges and incorporates a user’s expertise as a potentially useful source to inform the design, often utilizing different forms of knowledge elicitation, cognitive task analysis, or design storyboarding for translating users’ knowledge into design.

McNeese and colleagues (1992) chose a new approach termed group-centered design – an adaptation of user-centered design wherein groups (as social units) participate in the design of CSCW systems. Here, groups are used to understand the social construction of knowledge in their workplaces. Knowledge is acquired from the group ethnographically while still utilizing the group as multiple participants involved in improving their work practices. This is similar to many views today that employ in-situ, ecologically-valid understanding and development of collaborative systems-products (e.g., Hutchins, 1995; Schmidt & Bannon, 1992).

2 Methods

Assessing the above approaches retrospectively, each has varying elements of value and worth, depending on the researcher’s desired outcome. A typical result, however, is that these approaches often are not informed by each other, exist in isolation, and generally distill into a one-dimensional understanding of cognition, work, and technology. McNeese and colleagues have advocated the use of the Living Laboratory Framework (McNeese, 1996) to espouse a broader, interdisciplinary view of CSCW, and to produce multi-dimensional alternatives that are complimentary with one another. Essentially, the Living Laboratory approach is used to create an understanding of the intentions, goals, values and beliefs that drive individual behavior in the context of work and how these characteristics alter and influence patterns of behavior and modes of understanding when the situation for interaction involves teamwork. Figure 1 illustrates the Living Lab framework, which congeals unique dimensions of work and designs from multiple perspectives, shows their interconnections, and depicts how they inform each other, generate feedback and feed-forward loops, and act to integrate theory, models, use, and practice to access multiple levels of analysis.
Figure 1: The Living Laboratory Framework

Historically, the Living Lab vision is related to the ideas and research approach of Suchman (1987), who suggested that cognition and collaboration come about not by symbolic systems and plans, but through situated actions that arise during the course of events occurring in a particular context. Specifically, Suchman was referring to cognition that is constructed by social processes and situational contingencies, rather than that which is bounded by the individual brain or mind (Resnick, 1991). This view highlights the qualitative and naturalistic components of what people actually do when they work together and is often referred to as distributed cognition (see Salomon, 1993). Thus, the Living Laboratory framework is necessarily bound to approaches that are described as ecological, participatory, and ethnographic in nature.

The four elements of the Living Lab, working in concert, produce emergent layers of activities that mutually inform technology-, data-, user-, and group-centered elements of cooperative work. Notably, practice and use are tightly interwoven by these four components; the output from one becomes the input for another. The process is cyclic, but flexible enough to move forwards, backwards, and crosswise between components. The value of the Living Lab approach resides in its ability to address distributed cognition settings wherein information is dispersed broadly across time, space, and individuals. Typically, these settings require the effective design integration of (1) systems that enhance situation awareness and cognitive readiness, (2) supportive technologies (e.g., information, communication, and collaboration technologies), (3) knowledge management strategies, and (4) safe work practices.

The general premise of the framework is that both the observations of users or teams in their work domain, along with the knowledge acquired from them, provide the basis for ecologically valid simulations. Simulations become synthetic task environments that allow for theories of the user to be empirically tested within an actual context of use. These scaled worlds can also incorporate the use of partially defined design prototypes to assess hypotheses formulated on the ability of these prototype environments to enhance or constrain cognition or collaboration. Designs evolved from studies may be set in place to evolve lab infrastructure for use in future studies, or tested operationally in situ. The feedback and results generated by these studies are additionally useful for future theory, model, and tool building.

Owing in part to the natural, everyday constraints faced by most CSCW researchers, it may not be possible to apply every element of the Living Lab framework in a full-scale development. In an optimal situation, researchers are able to follow the arrows of interconnectivity as they progress towards a robust solution that satiates the refined problem. The process of utilizing the Living Lab is one of learning and discovery wherein answers inform and leverage other aspects of the problem-solution space. Applying the Living Lab perspective to CSCW enables researchers to focus on the mutual interplay of understanding, modeling, and measuring collaboration, perception, and cognition within complex systems.
3 Applications

Our current research concentrates on the development of CSCW systems, designs, tools, and interfaces to support teamwork in the emergency crisis management and homeland security domains. Presently, our projects correspond to a single cycle through the Living Lab Framework, and represent our goals of understanding work in these domains and designing appropriate solutions. These projects compare and contrast processes across collocated and distributed teams, and feature work on information, communication, and collaborative technologies that can enhance team cognitive processes that frequently incur under time pressure, emerge as a function of new information seeking, and are subject to multiple constraints and uncertainties.

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3.1 Ethnography/Fieldwork: Emergency Management Centers

As a launching point for the Living Lab, we performed an ethnographic research study focused on the interactions, responsibilities, and responses of emergency dispatch workers in emergency management centers. This venture has included multiple scenario-based interviews and observation sessions of 911 call center dispatchers as they perform their daily tasks in emergency response. Among the tasks studied is the allocation of resources to various types of emergencies and their associated relay of information to police officers, fire officials, and paramedics during emergency situations. These sessions with 911 dispatchers have resulted in the acquisition of information about possible responses toward various emergencies, the different functions and capabilities of emergency resources, and the development and refinement of emergency scenarios and storylines (see Terrell, McNeese & Jefferson, 2004, for more).

3.2 Knowledge Elicitation: Intelligence and Image Analysts

Another endeavor of our research in emergency management systems has included consultations with experienced intelligence analysts with backgrounds in several areas. The nature of the intelligence analyst domain is like similar fields that involve intense decision-making processes, and requires domain-specific knowledge elicitation in order to generate a relevant testbed for implementing effective analytic tools and procedures for aiding the accuracy of modern intelligence reporting. The responsibilities of intelligence analysts involve the evaluation of past and current global trends, events, and activities so as to prevent, detect, and respond to terrorist activity. We conducted intensive scenario-based knowledge elicitation sessions with intelligence analysts to obtain information regarding their daily work activities, interactions, and procedures related to their evaluations of information indicative of terrorist activity. Similar to other research conducted with intelligence analysts (Clark, 2004; Heuer, 1999; Kent, 1949), our work identified several notable characteristics in this domain including multi-source information fusion, cognitive analysis of complex information, and team collaboration in decision-making (see Connors et al., 2004, for more). Future plans for this research include knowledge elicitation sessions with novice intelligence analysts to compare their problem solving and decision-making procedures with that of experienced analysts.

Our most recent initiative with emergency management experts has involved interviews with image analysts from a federal contractor. Akin to the knowledge elicitation sessions with previously mentioned subject matter experts, elicitation sessions with the image analysts were conducted via scenario-based methods to acquire knowledge regarding the responsibilities of the analysts. Formally, these analysts focus their efforts on the identification of objects in aerial images of geographical regions of political consequence. The regions of interest are defined by military, governmental agencies or industrial customers that request the services of image analysts. Oftentimes, analysts are procured for the purpose of detecting evidence of terrorism or warfare activity within a geographic area.
Our research has uncovered pertinent principles, ideas, knowledge, and constraints on image analysts’ activities (see McNeese et al., 2004). This knowledge elicitation project, as an extension to the previous work with intelligence analysts, highlights in general some of the innate differences between intelligence and image analysis processes. Continuing to work with multiple types of analysts across fields of practice within the intelligence community provides an integrative thread for uncovering the cognitive and collaborative basis of complex work. Similarly, the results of these knowledge elicitation sessions directly inform the development of scaled world simulations and reconfigurable prototypes (e.g., cognitive tools, collaborative systems) as per the Living Lab.

3.3 Scaled World: The NeoCITIES Simulation

NeoCITIES, an updated and extended simulation based on the CITIES task developed by Wellens & Ergener (1988), is a synthetic task environment being designed to conduct empirical research on distributed cognition. NeoCITIES features an adaptable problem interface1 (an example is shown in Figure 2) designed to allow researchers to closely examine team behaviors, identify patterns of response to time-stressed situations, and monitor the performance outcomes of semi-autonomous, spatially distributed, decision-making teams. Users participating in NeoCITIES are presented with a wide-variety of overarching, emerging, dynamic, and detailed resource allocation problem scenarios. To solve these events, teams are required to meet the needs of their given constituents and develop situational awareness, while working around various problem space constraints related to the underlying emergency crisis management scenario. At its core, NeoCITIES is a team resource allocation problem designed to mimic the emergent situations that comprise real-life emergencies and measure decision-related outputs in a virtual environment. For example, the simulation will be used to explore how distributed teams make use of visuo-perceptual representations to anchor understanding of complex, ill-defined problems (what we have referred to as “perceptual anchors”) and in turn discover how such aids facilitate the successful transfer of information for subsequent team communication and decision-making. The simulation emulates the complex functions involved in the resource management of a city’s emergency services as well as command and control environments. As such, NeoCITIES provides an adaptable task structure which enables researchers and other end users to tailor the scaled world to meet the requirements for an operationally relevant context (see Jones, McNeese, Connors, Jefferson & Hall, 2004, for additional treatment).

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1 The term adaptable problem interface indicates that investigators are able to adaptively control various parameters and problem elements within the simulation to easily alter experimental conditions.
The design of NeoCITIES has benefited from the knowledge elicitation sessions held with real-world subject matter experts from emergency management and the intelligence community. This is in addition to the ethnographic field studies that examined actual emergency crisis centers in Pennsylvania, at both the local and state level, to understand the context, constraints, and dynamics employed in actual emergencies. By following the feedback trails of the Living Lab, these efforts have enabled our team of researchers to design system that support distributed situated cognition for an emergency 911 call center and acts of terrorism (e.g., September 11th) and develop an associated understanding of community-based resource allocation scenarios. Ultimately, the underlying storyline structure of NeoCITIES is informed by the results of our ethnography and knowledge elicitation efforts.

3.4 Reconfigurable Prototypes: The Collaborative Suite & Intelligent Group Interfaces

There is a logical relationship between the scaled world environment and the reconfigurable prototype stage that we hope to exploit. Within Cognitive Systems Engineering practice, designs are first envisioned then implemented via several forms of representation - from more primitive ideas to more workable design solutions. It has been our practice to first envision ideas directly from experts in the knowledge elicitation stage of the Living Lab. For example, our initial design ideas are typically represented as concept maps that are reified into designs of software. Through the use of scenario development or design storyboarding, these techniques help distill the primitive software artifacts we envision. At the point an envisioned software design reaches this more evolved, functional, working state, the application may be embedded in the scaled world simulation to test the initial feasibility and evaluation of technologies prior to being fielded in actual practice via a reconfigurable prototype. Therein, many of our designs and technologies live first in a scaled world where they are subject to experimental assessments that lead to further design improvements.

One of the newest technological ventures we are exploring is the concept of a collaborative suite. The suite, adapted from a design by D. Kirsh and colleagues (personal communication, March 31, 2004), consists of laptops or small form-factor (SFF) computers equipped with digital video cameras and LCD projectors. Live video is streamed across a network to distributed spaces from the cameras using hi-speed FireWire cables. The live feed, as well as any additional interfaces or windows, are projected onto a wall or screen, as illustrated in the figure below. We plan to extend this basic arrangement by including multiple input devices include Tablet PCs (with independent and shared interfaces) and an eBeam Interactive Whiteboard system, which allows for transmission of real-time sketching of concepts. The intent of the suite is to produce an alternative to other large group display technologies. Thus, unlike more cumbersome and expensive plasma televisions, the collaborative suite allows for transportation and is adaptable enough to represent possible field use in the homeland defense domain. We also aim to integrate a portable computer-assisted virtual environment (CAVE) into the suite to create a 3-D situated virtual reality across and within given spaces. Situated virtual reality expands what a user, team, or team of teams can perceive as it enables an elaborate sense surround that enhances information visualization of temporal, geospatial, and auditory data sets.

By combining these technologies into the collaborative suite, this portion of our work has the potential to represent a reconfigurable prototype of perceptual anchors within a technological substrate tailored to enhance team understanding and performance. Each respective technology employed in the suite centers on increasing the capabilities of distributed and colocated teams as they attend to emergency crisis situations. In the future, such applications could be integrated into mobile handheld devices to further increase portability and utility. In accordance with the Living Laboratory approach, we plan to experimentally investigate the usability of the collaborative suite technologies in the domain of emergency crisis management by integrating suite components into NeoCITIES to create a robust testing environment.
The intelligent group interface (IGI) is envisioned as a computational artifact that will blend diverse features from adaptive user interfaces, intelligent interfaces, groupware, and other collaborative technologies. The IGI may be thought of as the software architecture that serves as the foundational complement to the collaborative suite. As such, the IGI will adaptively allocate collaborative functions according to team information needs and contextual variations. The IGI represents the culmination of an interdisciplinary group-centered approach that fuses cognitive engineering, human-computer interaction and CSCW together to produce a viable technological solution for the homeland defense domain. Lessons learned from our fieldwork and knowledge elicitation of experts in homeland security and emergency management domains will be used to inform the creation of the IGI as well as NeoCITIES. Similarly, in keeping with the framework of the Living Lab Approach, NeoCITIES will be used as an experimental task to test and evaluate the IGI for collaborative knowledge management studies. In turn, data from these studies will be used to develop an improved understanding of our designs and solutions as we continue to cycle around the Living Lab framework.

4 Conclusions and Future Work

This paper presents the Living Laboratory approach as a unique research program framework that focuses on envisioned designs of collaborative technology that can facilitate distributed cognition in environments where teamwork is critical and complex. If we refer back to Figure 1, notice that each element described within this paper has spiraling connections with potential beyond our current status. For instance, the central purpose of the ethnographic investigations was to develop an understanding of emergency response practices, such that these situations could be emulated in the NeoCITIES simulation. In so doing, NeoCITIES will not be limited to experimental purposes. Rather, it can be utilized as a training and industry tool for dispatch operations. Future plans for this initiative include research focused on the collaborative efforts between local, state, and national emergency management systems as well as ethnographic observations of field workers such as police officers, fire officials, and paramedics.

The aim of our knowledge elicitation efforts was to facilitate direct transfer of knowledge and expertise of subject matter experts into our simultaneous development of the NeoCITIES scaled world simulation. In order to accomplish this objective, we have implemented a group-centered approach in which information from subject matter experts in emergency management is acquired to advance the development of supportive technologies. However, coupled with parallel research on fuzzy cognitive maps (Perusich & McNeese, in press), analysis of these sessions has fostered the development of an intelligent aid application for implementation into NeoCITIES (Jones, Jefferson, Connors, McNeese, Perusich & Obieta, under review). The aid would support situation awareness and cognitive readiness, which could be used later in envisioned designs to inform an appropriate implementation of the intelligent group interface. Similarly, the aid would give users access to expert knowledge as they attempt to respond to situations presented within NeoCITIES.
All of our activities serve to improve the realism, design, and utility of NeoCITIES. In order to ensure an accurate representation of emergency management system activities in NeoCITIES, we seek to obtain and incorporate the knowledge of subject matter experts from multiple realms of emergency management. It is our stance that the acquisition and utilization of expert knowledge is vital for efficient technology design. This research program has produced several advancements that focus around the use of the Living Laboratory Approach as a framework for conducting our investigations. We have made progress in the areas of theory, development, use, simulation, envisioned designs, and elicitation of expert knowledge specifically in crisis management. One might ask, to what end? The focus has been to enable a deeper understanding of collaborative knowledge management in a way that leverages the development of intelligent group interfaces and collaborative suites to facilitate decision-making and situation awareness within distributed, virtual teamwork settings.

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6 References


