

## **Coping with Software-Intensive Systems**

### **Design, Design Communities, Meta-Design and Social Creativity**

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In our Center for LifeLong Learning & Design (L<sup>3</sup>D), we have studied design for the last twenty years, particularly in the context of *software-intensive* systems. We have engaged in numerous interdisciplinary research efforts (including researchers and practitioners from: computer science, cognitive science, psychology, sociology, architecture and urban planning) focused on design. We have integrated theory development, systems building, practice, and assessment in our work to gain a deeper understanding of design. We have explored *the design of software-intensive systems as the objects of our design research*, and we have created *software-intensive systems supporting design* in numerous application areas.

My contribution to the workshop will be focused around the themes briefly outlined below.

#### ***Design***

Design is a ubiquitous activity that is practiced in everyday life as well as in the workplace by professionals. It is not restricted to any specific discipline, such as art or architecture, but instead is a broad human activity that pursues the question of “*how things ought to be*”, as compared to the natural sciences, which study “*how things are*”. It is a fundamental activity within all professions. Designers solve problems. But apart from problems in school, most *problems in real life are encountered, not given*. For these problems, understanding the problem *is* the problem. Real-life problems must be *framed*, a process in which the important objects are determined and desired outcomes are defined.

#### ***Design Environments***

We have developed *domain-oriented design environments* that model specific domains (such as software reuse, computer networks, user interfaces, kitchens, and voice dialog design) by allowing designers to engage in authentic tasks from their own respective work practices. Domain-oriented design environments allow computers to be “invisible” enabling designers to communicate with domain-specific concepts, representations, and tools. By bringing objects closer to the conceptual world of their users, the domain orientation of these environments makes high-functionality applications more usable, more useful, and more learnable. Domain-oriented design environments integrate a number of components relevant to a science of design: *specification components, critiquing components, cased-based libraries*, they use the evolving artifact as an indication of the user’s intentions (thereby providing an opportunity to infer high-level goals from simple user actions), and they support *reflection-in-action*.

## ***Design Communities***

Design projects and designed artifacts, given the nature of their context (wicked problems, change, unique characteristics, and multiple stakeholders) often evolve over long periods of time. Complexity in design arises from the need to synthesize stakeholders' different perspectives of a problem, the management of large amounts of information relevant to a design task, and understanding the design decisions that have determined the long-term evolution of a designed artifact. The knowledge associated with this type of design problem is distributed tacitly among the various stakeholders, each of whom possesses an important and yet incomplete understanding of the problem. Therefore complex design problems often cannot be solved by individuals or by homogenous groups. *Communities of interest* (defined by their collective concern with the resolution of a problem) bring together stakeholders from different *communities of practice*. Reaching a common understanding between these stakeholders is a major challenge in design.

## ***Meta-Design***

Meta-design characterizes objectives, techniques, and processes for creating new media and environments that allow the owners of problems to act as *designers*. A fundamental objective of meta-design is to create socio-technical environments that empower users to engage in informed participation rather than being restricted to the use of existing systems. In design processes, two basic stages can be differentiated: design time and use time. At *design time*, system developers (with or without user involvement) create environments and tools. At *use time*, users or “stakeholders” use the system but their needs, objectives, and situational contexts can only be anticipated at design time, thus, creating a system that often requires modification to fit the user’s needs. In order to accommodate unexpected issues at use time, systems need to be *underdesigned* at design time.

## ***Social Creativity***

The power of the unaided individual mind is highly overrated. Although creative individuals are often thought of as working in isolation, much of our intelligence and creativity (including the design of software-intensive systems) results from interaction and collaboration with other individuals. Creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a socio-cultural context. Situations that support social creativity need to be sufficiently open-ended and complex that users will encounter breakdowns. As any professional designer knows, breakdowns—although at times costly and painful—offer unique opportunities for reflection and learning. To make social creativity a reality, we have explored new forms of knowledge externalization, integration, and dissemination based on the observation that the scarce resource in the information age is not information—rather, it is the human resource to attend to this information.

## ***Author’s Background Relevant to the Workshop***

I have been interested in design throughout my whole professional career. I have published numerous papers about the topic of design (for details see:

<http://www.cs.colorado.edu/~gerhard/papers.html>).

I have directed several major research projects focused on design, and I am serving as the director of a research center focused on lifelong learning and *design* (for details see:

<http://www.cs.colorado.edu/~l3d/>).