Complexity in Interaction Design

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CHI 2007, April 28 – May 3, 2007, San Jose, USA
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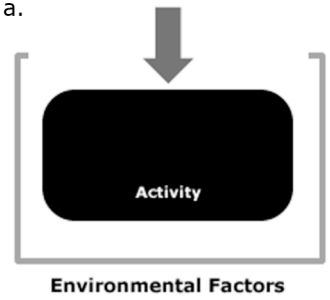
Abstract
The natural world is filled with examples of complexity, a notion that new system behavior emerges from the local interactions of its many similar parts. This phenomenon translates to the artificial world as well. When examined in conjunction with established theories from human-computer interaction, complexity offers a unique perspective to system design that can aid in the development of online communities. In particular, this research looks at new views of design resulting from the combination of key concepts—*situated action, flow, emergence* and *self-organizing criticality*—and offers a way to understand the dynamics of a member-driven system. The principles that result provide the foundation for complex interaction design (CXID), an approach elevating the importance of local interaction as the key driver in self-organizing dynamics of large-scale user communities.

Keywords
Complexity, design theory, situated action, flow, self-organizing criticality, emergence, framework, online community, critical mass.

ACM Classification Keywords
H.5.3. Group and Organization Interfaces: Theory and models. H.5.2 User Interfaces: Theory and methods.

a.



b.

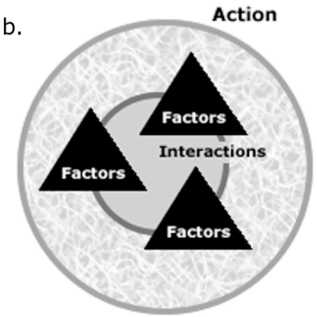


Figure 1. Suchman views activity not as (a) an object able to move from context to context, but as (b) the outcome of interactions between objects and resources in a context. In this sense, activity can be seen as the emergent property of interaction.

Introduction

While human-computer interaction design focuses on improving user experience, HCI techniques and methodological approaches toward system development largely reflect a top-down strategy. If one wishes to create a fundraising web site, for example, the underlying assumption is that the central mission is both the motivation and the obligation of community members. User experience is perceived as an incentive to align with the prescribed activity.

Complex Systems (CX)—the study of systems with many component parts interacting locally to produce unplanned macro behaviors—presumes a bottom-up construction. Behavior emerges out of many interactions. Changes at the local level over time also generate forces in opposition, a dynamic that can have a self-organizing effect to keep the system hovering around a desired state of equilibrium. From this perspective, raising money through the new fundraising web site is the result of individual user actions spurring the dynamic forces pushing and pulling the system into a state of collective giving.

In other words, traditional HCI sees the mission dictating the interaction while CX expects the interactions to create the mission.

This paper provides an overview of existing and derived theory that serves as the foundation for *Complex Interaction Design* (CXID)—a systems approach to development that emphasizes local interaction and its role as the key driver in the self-organization of large-scale multi-user communities. In particular, two pairings of CX and HCI concepts—*emergence-in-action* and *critical flow*—are offered as a way to understand the dynamics of a member-driven system.

A Human-Computer Interaction View

The domain of HCI is ripe with theory describing interactions between people and user interfaces. Among them are Lucy Suchman's theory of *Situated Action*—which describes activity in terms of its physical, social, cultural and historical context—and Mihaly Csikszentmihalyi's concept of *Flow*—a user state of "being in the zone."

Situated Action

When we view an action as an embodied object, we might take that action, put it in a box representing the conditions of its environment (see Figure 1), and have it act a certain way. If we put that action in a different box, or put a different action in the same box, new things happen.

Suchman describes action as an outcome rather than an intention, something arising from a context in which actors and resources interact. Planning does not impact actions directly since a plan can only reflect what has already happened and anticipate what is to come [5]. In the moment, activity doesn't exist. The context *is* the interaction.

Flow

In a 1996 interview with *Wired*, Mihaly Csikszentmihalyi described *flow* as a state where "[y]our whole being is involved, and you're using your skills to the utmost [3]." Csikszentmihalyi came to this idea while examining how creativity works. Flow has since been applied to product and interface design, including web

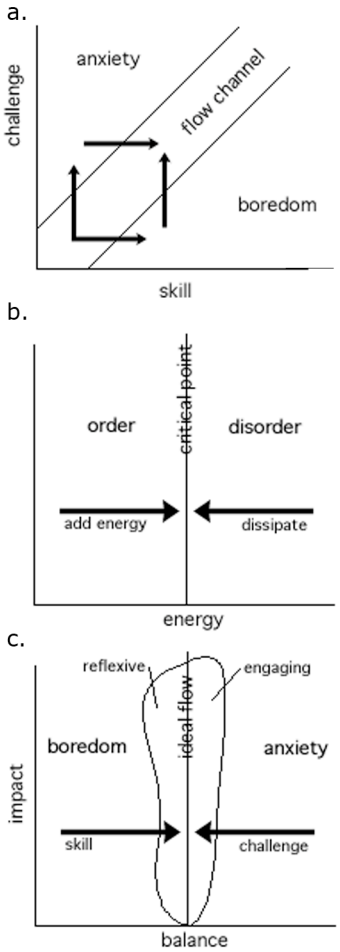


Figure 2. Critical Flow is the region between boredom and anxiety. A community moves in and out of critical flow as the relationship between perceived skills and challenges changes at the local member level.

sites, as the ideal experience that makes people form attachments to the things they use.

In his original flow diagram (see Figure 2a), Csikszentmihalyi graphs an individual's perceived challenges against her set of skills. When the challenges are much too great for the skill set, anxiety results and the experience is not enjoyable. When the skills are too great for the challenges, boredom sets in. In the areas where the skills are comparable to the challenges, the person can achieve a state of flow [2].

A Complex Systems View

The natural world is filled with examples of complexity, a notion that new system behavior emerges from the local interactions of its many similar parts. Designers don't often think of user interfaces as facilitating emergence, but there may be benefit to doing so, especially when the system being built is a community of many members. CXID draws from a core definition of complexity and the notion that some complex systems will self-organize around an ideal state where interesting things occur.

What is Complexity?

A common illustration used to explain the difference between *complication* and *complexity* is an airplane. The airplanes in use today are complicated. Many parts work together to create flight, but the plane flies by design, with specific components playing vital roles in that function. Remove any of its thousand components, and you run the risk of breaking the machine.

If one could imagine a *complex* plane, however, its flight would arise out of the interaction of many similar parts. Removal of one is unlikely to affect its ability to fly—flight is emergent from many interactions, not engineered by assignment of tasks. Such a machine might be less predictable but also less susceptible to failure of a specific component. Complicated systems are deterministic, but one cannot control with precision the outcome of a complex system.

Complexity is the study of many-bodied systems achieving points of criticality, where local interaction has long-range effects and emergent properties [4].

Self-organizing Criticality

Another characteristic of complexity is change over time. Dynamics are evident in *Self-organizing Criticality*, a concept first detailed by Per Bak, Chao Tang and Kurt Wiesenfeld in 1987. Through modeling sand pile avalanches, they discovered that the reason some systems hover around a critical point—the spot where order and chaos are delicately balanced—it is not due to an discrete tuning of environmental conditions [1]. The criticality exists because of a tension in dynamics created by the component interactions.

The critical point arises from a *driven-dissipative* system (see Figure 2b). That is, the force responsible for accumulating energy in the system operates much more slowly than the force that dissipates that resource. A common example of this is an earthquake. The critical point typically exhibits important, recurring properties of complexity, such as power-law distributions and scale invariance.

Towards a Framework of Complex Interaction Design

This theoretical research builds upon these core concepts from HCI and CX to construct a possible

framework for future community design. Some of the influential hybrid concepts include:

Fuzzy Determinism—While it is not possible to measure or track every individual particle, models and simulations can be used to understand system dynamics and the impact simple rules have on emergent behavior. Change a rule; get a different behavior. Change the right rules, and specific behaviors emerge.

Emergence-in-Action—Desired system behavior can be viewed as the result of many actions that arose from many individual user contexts. CXID sees communal behavior not as engineered functionality but as a natural aggregation of individual experience.

Critical Flow—We can re-orient Csikszentmihalyi's flow diagram to resemble a phase transition around a critical point (see Figure 2c). The tensions between perceived challenge-skill and aversion to boredom-anxiety generate the forces that push a community member in and out of the flow state.

A Framework for Community Design

These new concepts can inform the creation a framework for the design of online communities: *emphasize the local*, *maximize the rate of interaction*, *live between the tensions*, and *engage through disengagement*. These guiding principles are not generated from evidence available in existing communities (although some systems, like Twitter, may prove good exemplars). Instead, the framework is proposed to help future design of such spaces.

Conclusion

Through CXID, we can gain a new perspective on how to frame the creation of online community. This is accomplished by recognizing the value of a combined perspective offered by CX and HCI theories. The key insights are: local rule changes affect system dynamics; system behavior arises out of user interactions; and dynamical forces can act to keep a system hovering around an ideal state. The design framework that results is not meant to reflect current community design but instead might be used to guide future development or refinement of existing communities.

Acknowledgements

I thank Eli Blevis, Alex Vespignani, and my fellow graduate students at the Indiana University School of Informatics for their feedback and inspiration.

Example citations

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[5] Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communications.* New York: Cambridge University Press, pp. 49-67.

Expected Benefits of Participation

The CHI Doctoral Consortium is a wonderful opportunity to receive and provide feedback on dissertation works-in-progress from peers and knowledgeable faculty mentors. Since my area of interest involves bridging two rather disparate communities of complex systems and human-computer interaction, it is vital to the success of my work to be able to effectively communicate the concepts imported from the CX domain. I look forward to tapping the collective experiences with interaction design techniques, methods and theories to measure against my own theoretical ideas as a test of their value. Most importantly, I anticipate giving to other dissertation projects with the same fervor, offering my own unique perspectives on the work of other students. The connections made through the CHI doctoral consortium will live beyond the two-day activity, both in the form of advice and future collaboration.