Ability-centered design: from static to adaptive worlds

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After a long career in systems engineering and design, John Rheinfrank died on July 4, 2004.

John's Ph.D. dissertation explored what he called "organic systems theory," or what's now called "complex adaptive systems"—bridging multiple disciplines and theoretical frames (e.g., biology, computing, economics, psychology, and sociology). John spent most of his professional life applying principles derived from living systems to designing systems for people—from design languages that could serve as the foundation for a broad range of reprographic machines for Xerox, to personal information and communication appliances for Philips. In essence, he wanted us to design systems that are alive.

In the years since John's death, complex systems have become deeply engrained in our everyday lives, from Facebook and Twitter to the interconnected financial systems that plunged us into the credit crisis. When John learned he was sick, he began working on a book on the relationship between design and systems. Sadly, he never finished, but some of his core ideas were preserved in a presentation on moving from static to adaptive worlds. John saw adaptive worlds as a new way to frame interaction design, which makes it an important topic for interactions. This presentation was his way of helping us make the leap from the present to the future he could already envision. Working from John's presentation slides and a tape of his talk, we have summarized his ideas.

— Hugh Dubberly

The history of design is mostly the history of design-ing static worlds—objects, messages, and spaces that are fixed and invariant.

In a static world we are forced to adapt to the object. For instance, this chair is this height. It doesn't matter if you're short or tall—the height of the chair remains the same. Most chairs are still like this today. They are static objects. Your back and your butt must adjust to the chair. It is an object that we adapt to.

Along comes a new kind of chair. Not only can you turn in it, but you can also raise and lower it—or even tilt it to a position that is right for you. The designer's role expanded from that of arbitrator of form to creator of resources for interacting with the chair. This meant the designer had a whole new range of representations to account for and choices to make. Because now that we can adjust the chair, we are more comfortable as we work.

Many early interaction design efforts focused on making things simple for naïve users. The idea was to take resources for decision-making away from people—automating features in cameras, for example—to reduce cognitive load or how much users would have to think about what they were doing. Reducing cognitive load often comes at a price: limiting choice and possibilities for expression. For example, point-and-shoot cameras with one wide-angle lens, fixed focal length, single f-stop, and single shutter speed. This approach should raise ethical concerns for designers, especially when it "de-skills" people.

In the early days of the photocopier, the machines would often fail. Problems as simple as a paper jam (identified by a cryptic "Error E31" on the display) would require calling a trained service professional to come on site to open and repair the machine. A team from design consultancy Fitch-Richardson Smith, led by John Rheinfrank, helped Xerox shift its cultural paradigm away from training service professionals to embedding information in the machines so that the machine users could fix problems themselves, quickly and effectively. In essence, the redesign provided information that helped people learn to use the machine as they used it, by offering a rich set of resources for managing the process (in this particular case, in the event of an equipment malfunction).

Adaptive Worlds

A new order of systems is emerging, that adapt to the worlds in which they play a part. Although the form they take varies widely from example to example, these systems all have in common some means for: 1. "perceiving" two or more states of the environment in which they are embedded; 2. creating, based on these perceptions, a "model" of the environment around them; and 3. adapting, based on this model, in a fashion to best meet the performance objectives of the system in the face of a changing environment. This need not be a one-shot event—it can occur continuously over time. For example, multilevel digital games (the system) have access to the score achieved by a player (perception of the environment), and, knowing the level at which that score was achieved, can assess the player's skill level (creating a model) and adjust game difficulty in a way that keeps the player in the flow between boredom (this is too easy) and frustration (this is too difficult), which, ultimately, is the game designer's goal (adapting to meet a performance objective).

It is not much of a stretch to go beyond this simple adaptive system loop to incorporate additional means of manipulating a system's characteristics by the users engaging with that system (e.g., in our game example, consider the qualitative expansion afforded by Second Life). Dynamically co-constructed adaptive worlds give both creators and consumers the ability to design or improvise new activities that honor specific abilities as they emerge.

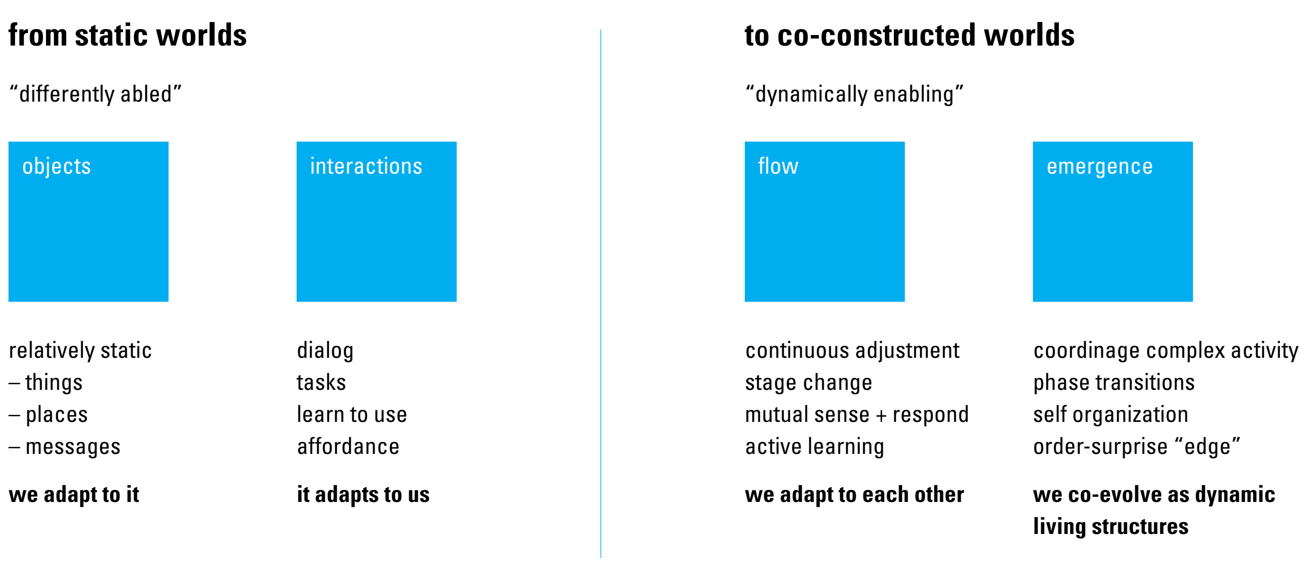
In John's words: "In this framework, we start to build worlds that collaboratively participate in the (co-evolution) of our individual and collective abilities. At the simplest level, we no longer are forced to adapt to the worlds in which we live, play, learn, or work. The worlds now shift to meet our abilities, to anticipate whatever they are or what we want them to be"[1].

John saw this "ability centered" framing of interaction as a way to enrich the user-centered notions that currently drive much of design. He felt that "user centered" focused on modeling explicit, articulated needs. Evaluating designs (usually specifications) against the articulated model was often seen as sufficient. With ability-centered design, the question is not What qualities of the user will allow them to perform this task in the easiest fashion? but rather, What are the latent, masked needs, the unobservable, inconceivable needs? In ability-centered design, functional prototyping and evaluation by end users are paramount.

What characterizes dynamically enabling adaptive worlds, and how can we even hope to design for them?

While static worlds are about objects and interactions, adaptive worlds are about flow and emergence. In a static world, objects are inflexible—they don't have the ability to change or adapt built into them. In an adaptive world, objects and processes modify themselves based

Figure 1 From static worlds to co-constructed adaptive worlds



on information gleaned from people, either through sensing or explicit input. A service experience in an adaptive world would feel as though it had been custom-designed for every person. As each visitor entered the store, the environment would sense them and inform the staff of their preferences, their past purchases, etc.

Dynamically Enabling Flow

When John spoke of flow, he was referring to Mihály Csíkszentmihályi's notion of flow[2]: a correspondence between you and what you're doing—where the challenge you face matches your ability. You enter into a separate mental space, and you move in a different way. You're in the "zone."

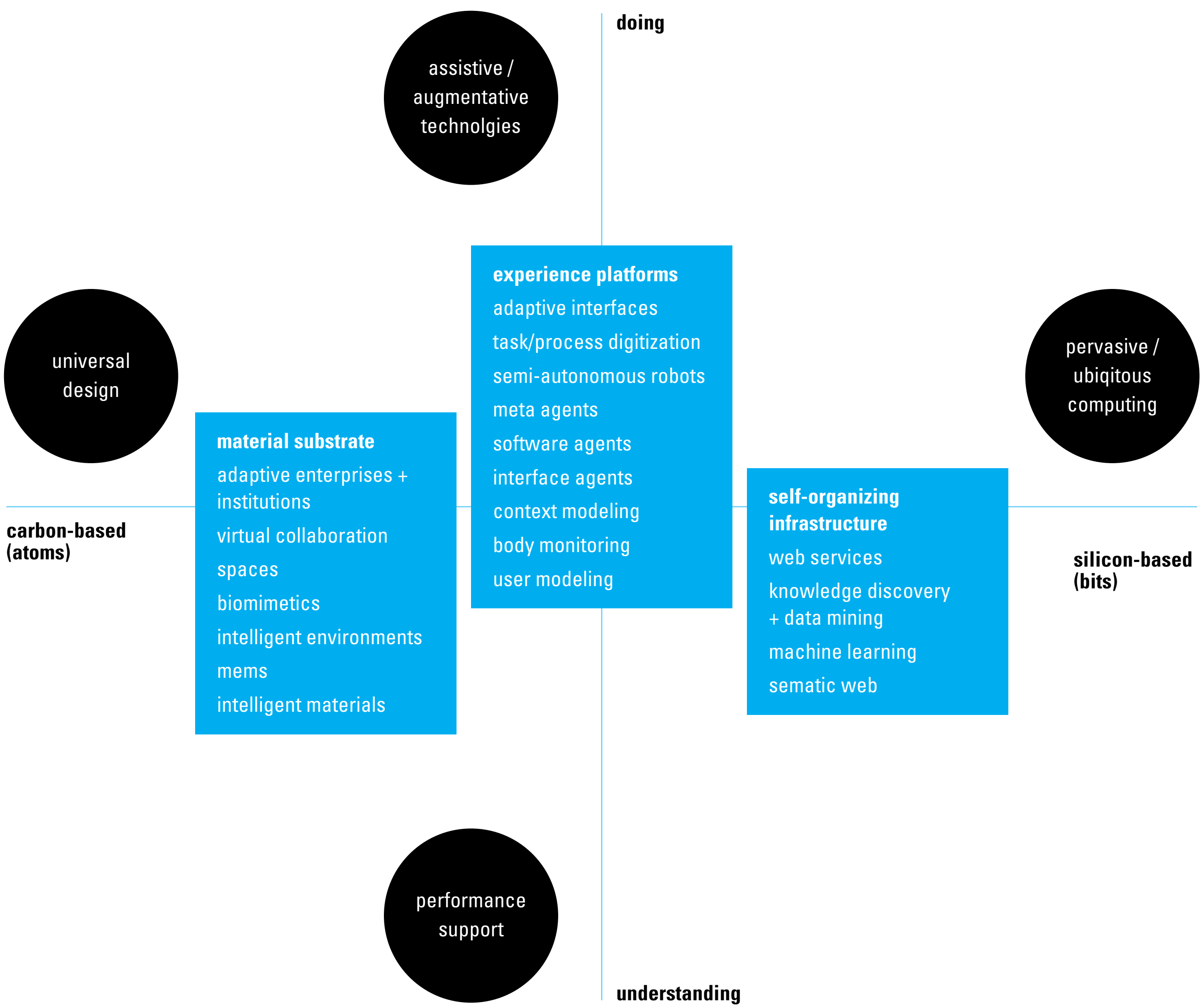
Now, as we shift to co-constructed adaptive worlds[3], there are the beginnings of an adaptation between the things that fill my world and myself.

There's also a shift in learning from passive to active. Passive learning is the assumption that people are empty vessels for instructors to pour information into—instructors deliver content and students receive or digest[4].

Active learning involves not just hearing or reading facts, but also doing things that put them to use in a way that makes them real for the learner. Active learning requires a participatory learning environment where learners and instructors "play," leverage their shared context, and co-construct knowledge in relation to each other and their experiences.

Advanced robots are just beginning to "learn" and adapt to the terrain around them, while constantly monitoring and adapting to mission-significant objectives like threats and the people they have to rescue. Another example of this new kind of system is financial tools geared toward consumers. These days, when you bring your money to a well-designed bank, the system evaluates your "life stream," a constantly changing model of how you and people like you act in your progressing stages of life. So as you and your life change—for example, you buy a car or begin a family—bank services are reconfigured for you. PNC Bank's

Figure 2 Adaptive worlds technology clusters



Virtual Wallet, based on the money mind-set and financial lifestyle of Gen Y, takes on some of these qualities.

Today the wallet helps people plan and save. The resources behind the wallet grow and change over the life of the user.

John believed "this dynamic can apply locally at the smallest scale and globally to the composite of forces that shape our lives. Until recently, we've done this coarsely, marginally, and at tremendous cost and over extraordinarily long time periods. We add handicap-access ramps to old buildings and design new buildings that seek to be barrier-free.

The limitations of these world-shaping objects define what it means to be disabled. The objects—our designs—quite literally create the disability.

This need not be so. The objects we can make today and tomorrow are no longer dumb in the exclusive light of our intelligence."

What John called "emergent systems" are an ecology or community of these adaptive systems, in which elements in the system learn, adapt, and share the knowledge they gain about the world with other pieces of the system. An example of this type of system is Google. The system shares knowledge from Web search to Maps search to Images search, to help you find the thing you are looking for as easily as possible. Many organizations behave as emergent systems, for instance, the governing system of the Internet. Each node doesn't hold enough power to sway the entire system, but as events arise, the standards and systems adapt to the emergent needs.

To explain the technology and trends that are enabling adaptive worlds, John mapped the elements across two axes. The horizontal axis is a continuum of materiality, from human being, thinking, and doing to machine being, thinking, and doing. The vertical axis represents the nature of the action you are undertaking, from understanding to doing. The elements on the bottom help you understand the system or the world better, while the elements on the top enable to you do things better. John provided four examples of trends that are moving toward complex adaptive systems.

Universal design is an example of a carbon-based emergent system. OXO created a line of kitchen tools specifically designed for the arthritic or the handicapped, but they ended up appealing to a much broader audience. People soon realized the OXO tools felt fantastic in the hand and made performing functions much easier and more enjoyable.

Ubiquitous computing is an example of a silicon-based trend. Ubiquitous computing is the increasingly embedded nature of sensors, processors, and networks in the physical objects that surround us, from medical equipment to our mobile phones.

A good example of assistive or augmentative technology is Dean Kamen's iBOT-powered wheelchair. The unique technology and orientation was intended to enable those with severe mobility problems to ascend stairs. Anyone who uses this device daily will also mention the unintended appeal of the device: the mechanism can readily lift the user to be eye to eye with anyone they interact with. Finally, an example of devices that help one understand better is the work done on Xerox machines. As noted earlier, the machine evolved into something that could teach users how to diagnose problems and quickly return the machine to a fully operational state.

John saw three different resources enabling adaptive systems. The first are the platforms for creating experiences, "the auto-catalytic foundation for co-constructing fluid, extensible interactions and meaningful relationships between people and hybrid physical/virtual worlds that matter to them." The second is the people, places and things that contribute and benefit from the adaptive worlds, what John referred to as the material substrate. Last are the underlying elements that make up the networks within adaptive worlds, infrastructures that are self-organizing rather than guided by outside forces. At least one component from each of these clusters is required for any adaptive emergent system.

We now have the capacity to design and build objects that are active, semi-autonomous, evocative, emergent, mixed-initiative partners in the (re) formation of worlds that are magical by today's standards.

Eric Schmidt, CEO of Google, recently suggested "people are not ready for the technology revolution that's going to happen to them." He was referring to the ubiquitous role of technology and the collection of data to enrich our interactions with the artificial. Many organizations, including Google, are under fire for provoking privacy concerns over the handling of their users' data. The complex adaptive systems that are beginning to emerge are a testament to the benefits of systems that can learn and engage in a dialog.

What does this mean for interaction design? More broadly, what does this mean for the systems we will interact with in the future?

John, when speaking to a group of present and future designers, said: "Don't be satisfied with my native abilities. Provide a setting in which my ability is extended ... Help me reveal my potential." He envisioned a world in which systems weren't designed for specific interactions, but instead designed for the latent potential abilities that exist in everyone. John continued, "Let me feel that it's alive. Don't hide it from me. Don't make it transparent." Living systems are inherently fallible and magical: We make decisions that end up being mistakes or happy accidents. One of the qualities of biological systems is their ability to acknowledge and react to these events. John believed that complex adaptive systems should react the same way: They should evoke the same feeling of "alive."

References and further reading

1
In biology, co-evolution is when one object changes in reaction to a change in another object. John used co-evolution to describe when two objects sense and respond in relation to each other and act accordingly. Most software designers today would be pleased with designing flexible systems— ones that have the potential to be changed in the future. Co-evolving systems—one with the potential to respond without direct input to change—are far more difficult to conceive and implement.

2
Mihaly Csikszentmihaly, *Flow: The Psychology of Optimal Experience*. New York: Harper Collins, 1991.

3
Co-construction is a social process in which people and objects and their relationships influence each other and impact potential outcomes. Service experiences are co-constructed. For example, each time a person walks into a Starbucks, they coconstruct the service experience in relation to the space, the objects, and the staff; if they are having a bad day, it can impact all the other customers in the store.

4
John Seely Brown, "The Social Life of Learning: How can Continuing Education be Reconfigured in the Future," *Continuing Higher Education Review*, Vol. 66, 2002; pp. 50-69.

About the Authors

Shelley Evenson is a design manager at Microsoft leading a team that explores real-time communication products that engage and connect people in new ways to help them communicate and collaborate. Before Microsoft she was an associate professor teaching interaction design at Carnegie Mellon University. Evenson taught courses in designing conceptual models, interaction, and service design, and collaborated in projects with colleagues from the Tepper School of Business and the Human Computer Interaction Institute. She jump-started the study of service design in the U.S.—designing courses, energizing students, and hosting the first international conference on service design—Emergence. Before joining the faculty at Carnegie Mellon University, Evenson worked for more than 25 years in multidisciplinary consulting practices on a wide variety of design and development projects.

Justin Rheinfrank is an interaction designer at gravitytank, an innovation consulting firm in Chicago. He has helped visualize and define exciting new interaction and service concepts for organizations like Google, Samsung, Mayo Clinic, and NASA. Justin graduated from Carnegie Mellon University with Masters and Bachelors degrees in Human-Computer Interaction and a Bachelors in Industrial Design.