# Toward a Paradigm Shift in Social Computing: The ACP Approach

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In a sense, social computing is a new research field with a long history. Its origins trace back to the beginning of modern computing and landmark work such as Vannevar Bush's Memex,[1] Douglas Engelbart's vision for integrating psychology and organizational development with computer technology advances,[2] and J.C.R. Licklider's emphasis on computers as communication devices, not computing machines.[3]

All these men are considered Internet pioneers whose contributions consist mainly of ideas, not inventions. Although none of them explicitly used the term "social computing," their ideas are reflected in recent directions in social-computing research.

## Two views of social computing

Figure 1 shows two schools of thought in this area. The first, which I call *social software*, centers on information technology. It focuses on applying knowledge from social studies to design and improve applications such as email, the Internet, and other computer-supported collaborative work. This is still the mainstream of social computing. To me, current social software and related studies, although powerful and sophisticated, are still primitive prototypes of Bush, Engelbart, and Licklider's pioneering visions.

The second school is newer, more social-sciences centric, and closely related to the emerging discipline of Web sciences.[4] This school emphasizes using IT to develop cyberphysical systems for studying and managing social behavior and organizational dynamics, especially in virtual worlds built over the Internet. These virtual worlds and the Web are pushing social computing into cyberspace and closer to full realization of the augmented human intellect and living spaces advocated by these Internet pioneers.

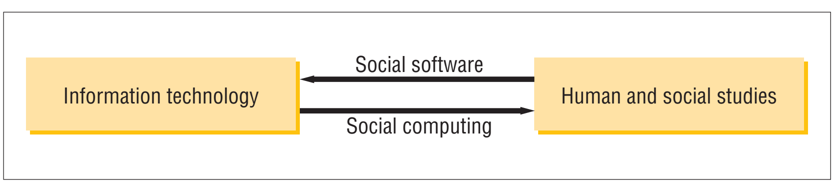


**Figure 1. Two schools of thought: From social software to social computing.**

## Why social computing now?

Above all else, the Internet has motivated this new direction, but two recent political events have also been critical. The first is the dramatic political reform in the former Eastern European Communist countries. In the early 1990s, TVs and fax machines became important in shaping societal dynamics online and in real time. This inspired RAND researchers to propose *artificial societies* as a research concept for studying IT's social impact.[5] They saw these simulated worlds as a social policy tool: "the most important policymaking over the next several decades will occur at the intersections of the information technologies and social change."

The second event is the 11 September 2001 terrorist attack in the US and subsequent attacks in other parts of the world. The Internet and mobile communications played a crucial role in the planning and execution of these attacks and in the speed and scale of their impact on people and societies. This motivated University of Arizona AI researchers to initiate a new area of study: *intelligence and security informatics*. ISI employs methods and tools developed in bio- and medical informatics for security issues ranging from the international to the personal and from the political to the economic.[6]

## The ACP approach

We need a new science for social studies of integrated cyber and physical worlds. In these worlds, information spreads at the speed of light and reaches every corner of the earth. Organizations involving tens of thousands of people can emerge overnight or even in minutes, and any individual who can click might have an equal or even bigger voice than a powerful government. In a sense,


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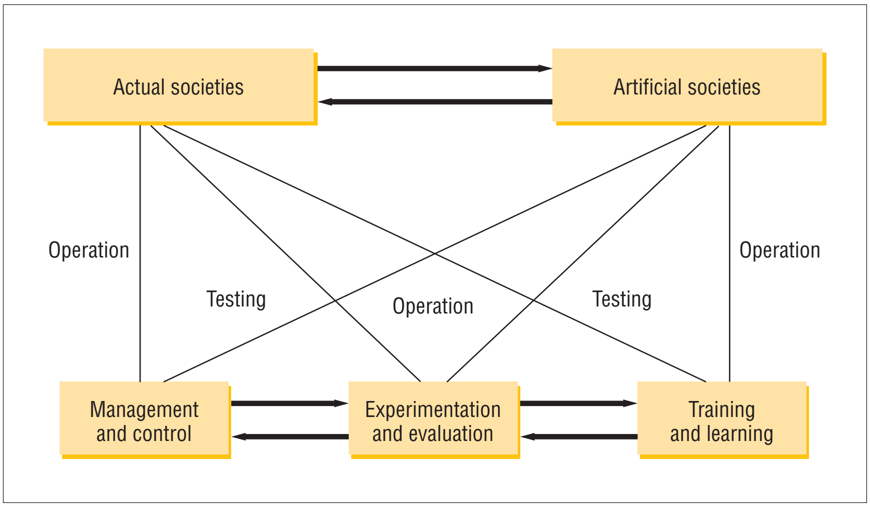


**Figure 2. Parallel execution for control and management in social computing.**

cyberspace has facilitated, if not instigated, a fundamental shift in political power in human societies, which users can exploit for good or bad. The new science must be equal to these situations and challenges, emphasizing real-time dynamics, closed-loop feedback, and executable decision support.

Information and social sciences have performed much research in this direction. However, to achieve a paradigm shift in social computing, I propose adapting the three-stage modeling, analysis, and control approach that researchers have used successfully to solve many natural and engineering science problems. Here, I describe what I call the ACP approach: artificial societies for modeling, computational experiments for analysis, and parallel execution for control.

## Modeling with artificial societies

There are as yet no effective, widely accepted methods for modeling complex systems, especially those involving human behaviors and social organizations. Agent-based artificial societies or general artificial systems might be the most promising approach.

Modeling with artificial societies has three main parts: agents, environments, and rules for interactions. In this modeling approach, the accuracy of approximation to real systems is no longer the only objective, as it is in traditional computer simulations. Instead, the model society represented by an artificial system is considered real—an alternative possible realization of the target society. Along this line of thinking, the real society is also one possible realization. So, the behaviors of two societies, real and artificial, are different but considered equivalent for evaluation and analysis.

Of course, modeling with artificial systems doesn't exclude exact descriptions of target systems. Actually, approximation with high accuracy is still the desired goal for many applications when it's achievable. The idea of equivalent behaviors is a forced compromise that recognizes intrinsic limits and constraints when dealing with complex systems.

## Analysis with computational experiments

Traditionally, social studies often use passive observations and statistical methods because conducting active tests and evaluations, let alone repeatable experiments, is difficult. Even when experiments are permissible, too many subjective, uncontrollable, and unobservable process factors can limit the validity and use of the corresponding results and conclusions. Because analytical reasoning can solve very few social-computing problems, finding an effective way to conduct experiments becomes critical for further development of social-computing research.

Modeling with artificial societies shows promise for this purpose. Using artificial societies, we can treat computers as social laboratories. We can design and conduct controllable experiments that are easy to manipulate and repeat; we can then evaluate and quantitatively analyze various factors in social-computing problems. These computational experiments are a natural extension of computer simulation techniques.[7] They require attention to basic design issues related to calibration, analysis, and verification. They also follow design principles such as replication, randomization, and blocking, just as experiments in the physical world do.

Researchers must address several important issues before we can use computational experiments effectively and widely in social-computing problem analysis. These issues include how to use agents to sample and interview a population, what polling techniques to adopt, and how to manage temporal-spatial distributions in virtual worlds.

## Control through parallel execution

By parallel execution, I mean one or more artificial systems running in parallel with a real system. This is a generalization of the industrial controllers applied in conventional automation, which use analytical models to drive targeted physical processes to desired states. Parallel execution provides a mechanism for the control and management of complex social systems through comparison, evaluation, and interaction with artificial systems. As outlined in figure 2, it involves three major modes of operation:

- learning and training, where real and artificial systems are normally disconnected;
- experimenting and evaluating, where the connections between parallel systems are on and off alternatively; and
- controlling and managing, where artificial systems try to emulate the real system such that you can use their behaviors to improve and optimize the actual process's performance in real time.

Parallel execution could use methods and algorithms developed in simulation-based optimization and adaptive control, such as rolling-horizon analysis and model-reference feedback control.

My colleagues and I originally proposed management based on parallel execution for complex social-engineering systems such as transportation systems, electrical power grids, ecosystems, and social economic systems.[8] It can handle the fast dynamics and extreme scale of cyberphysical systems, making it suitable for conducting and implementing social computing on the Web.

## Foundations in philosophy and physics

The call for such a paradigm shift would lead social computing into unknown territories of artificial entities. Although many might question the scientific value of conducting research with virtual worlds, figure 3 illustrates some ideas from philosophy and physics that could provide logical and disciplinary foundations for research in this direction.

Karl Popper, one of the greatest modern philosophers, proposed a three-world model of knowledge:

- world 1, the physical world of knowledge;
- world 2, the mental world; and
- world 3, the expressed or stated world of knowledge where humankind chooses artifacts to represent knowledge, which triggers further thought.

He further divides world 3 into three parts: world 3.1 for objects in world 1, world 3.2 for those in world 2, and world 3.3 for artifacts unknown to both world 1 and world 2. Social physics, introduced by Harvard linguist George Zipf, was an early attempt to establish physical laws for world 3 as we know them from world 1.[9] Just as natural physics provides laws governing motion in world 1, social physics will offer the foundation for constructing artificial societies. We could also view the parallel-execution concept as a practical utilization of the many-worlds interpretation that Hugh Everett envisioned for quantum mechanics 50 years ago.[10]

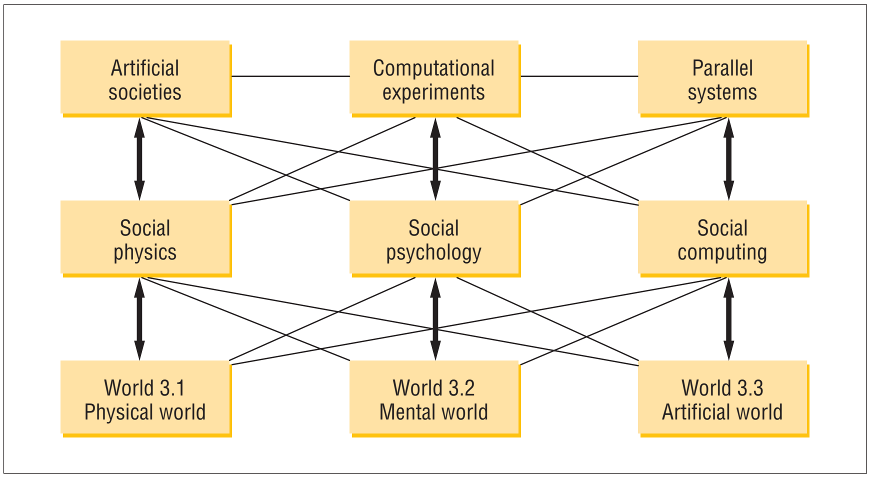


**Figure 3. Logical and disciplinary foundations for social computing.**

Over the past two decades, social software, from email to blogs, has fundamentally changed how we live, work, and interact with each other. Could social-computing research inspire revolutionary changes in how we conduct and use social studies? I have high hopes. As the American sociologist George Lundberg pointed out in 1939: "It may be that the next great developments in the social sciences will come not from professional social scientists, but from people trained in other fields."


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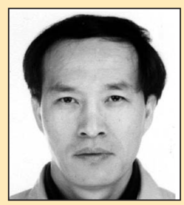


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