

Organization Session Report

Full Session Name: Organization of CI and CI-enabled Organizations

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I. Why is the study of CI and Organizations important to address the problems of Cyberinfrastructure for the social, behavioral, and economic sciences?

For the last few decades, science has been undergoing a paradigm shift. Many of the most exciting science discoveries today are the result of multi-disciplinary, team-oriented, science-driven and technology-enabled collaborations. Cyberinfrastructure with its need for integration, end-to-end performance, and coordination of its many components and constituencies, will require a functional organizational framework, including the development of appropriate management, oversight, incentive, decision-making, and other key organizational structures, to be successful.

Organizational analysis and research are critical to the successful development of cyberinfrastructure as infrastructure. Cyberinfrastructure as infrastructure does not – and cannot – exist without organizational, administrative, management and governance infrastructure. The latter are necessary to ensure cooperation and coordination when technologies fail to mesh, to allocate resources equitably within shared systems, to manage and resolve inevitable and potentially damaging disputes and conflicts. Although some elements of cyberinfrastructure will be self-organizing, many critical elements will require more formal organization. Research is needed to describe, explain, design and influence the critical governance and management structures that are an essential part of cyberinfrastructure.

It is also not the case that organizational design, structure and processes will remain stable as cyberinfrastructure is developed and used. Organizations, singly and in networks, are undergoing fundamental change as the cyberinfrastructure enabling radically types of information collection, storage, communication and analysis is developed. It is imperative to understand, design and manage new organizational forms and arrangements resulting from and with cyberinfrastructure.

In addition to key roles as “process builders” of cyberinfrastructure, organizational researchers will be important “end-users” of cyberinfrastructure. Today, information and computational tools and technologies facilitate all aspects of the modern organization. Cyberinfrastructure has the potential to provide a new level of organizational capability for enterprise systems, workflow control, supply chain and provisioning, archiving and records management, and other organizational components. Cyberinfrastructure provides immense potential for facilitating more capable and more successful organizations.

The high failure rate of large IT projects and their tendency to overrun budgets points to a strong need to avoid such failures when building and using cyberinfrastructure. Strong empirical

evidence demonstrates that the sources of failures and cost overruns typically are organizational and managerial rather than technological. The higher level of complexity of cyberinfrastructure demands a commensurably higher level of organizational and managerial knowledge and expertise.

II. What are the opportunities and challenges in organizational research and practice with respect to cyberinfrastructure for the social, behavioral, and economic sciences?

Achieving the potential of the application of both organizational research and practice to cyberinfrastructure, and cyberinfrastructure to enable organizations presents immense opportunities and challenges. The opportunity for using organizational research to help frame a functional and successful cyberinfrastructure would provide the critical framework needed to achieve the vision of cyberinfrastructure compellingly described in the Atkins Report. The ability to use expertise, tools, and technologies effectively, in a coordinated fashion, and at a level of performance which facilitates user goals is key to achieving this vision of the future

There is also an opportunity to develop a fundamentally new body of theory and research on organizations. The organizational fields affected include all levels of analysis that inform understanding of organizations: At the micro levels, and with respect to individual and social psychology including individual behavior in organizations encompasses motivation, job satisfaction, organizational commitment, creativity, and related phenomena.

At the level of social behavior in organizations, research includes small group behavior and decision making (including virtual teams, knowledge sharing among groups and teams, communication and coordination patterns). At the level of the individual organizations, research questions encompass those concerning organizational design, leadership, command and control, innovation, adaptation and flexibility, and strategic planning. Finally, at the level of inter-organizational arrangements, or networks of organizations, cyberinfrastructure is a catalyst for research on network structures and behavior and their relationship to outputs and outcomes such as productivity, efficiency and innovation.

The range of organizational phenomena from micro- to macro-level are encompassed in the CI and organization research program. The research fields of importance span economics, sociology, psychology and political science as well as newer, hybrid subfields specifically oriented toward new manufacturing designs, new forms of team-based organizations, and innovation. Thus, such research programs are needed to extend the social, behavioral and economic sciences so that they account for changes in phenomena.

The challenges associated with organizational research and cyberinfrastructure are numerous. It is critical to develop functional frameworks which facilitate the vision of an effective cyberinfrastructure. Cyberinfrastructure is a complex system of human, hardware, and software resources often distributed, and with distinct administrative, control, and performance characteristics. It is a research challenge to develop the appropriate coordination and integration mechanisms to provide “end-to-end” performance, and to provide users the ability to leverage multiple coordinated resources to accomplish their goals.

Three particular challenges are noted here. First, cyberinfrastructure is changing rapidly making research sites moving targets and demanding *dynamic research designs*. Second, there is the inevitable danger of applying theories and research questions developed for a pre-cyberinfrastructure environment. The danger is that some theories, variables, and relationships are mis-specified when applied to newer forms of organization structured by CI, hence the need for *cyberinfrastructure-targeted research and theories*. A third challenge lies in an overemphasis on the technological construction of cyberinfrastructure while paying too little attention to social, behavioral and economic variables as both antecedent to and a consequence of CI, hence the need to develop *more comprehensive and holistic models for CI*.

III. What are the potential roles for the SBE and CISE communities in this area?

Both SBE and CISE can play key roles as research collaborators and expert consultants. Cyberinfrastructure is both an enabler and a target for new organizational research of interest to both the SBE and the CISE communities. As expert consultants, organizational researchers and practitioners are needed to help frame a functional cyberinfrastructure which provides adequate coordination and synergy of its components. Similarly, computer scientists and information technologists are needed to help frame CI-enabled organizations which have a greater capacity to communicate, analyze data, track and interpret information, etc.

IV. What are the recommendations from your session?

Four key recommendations emerged from the substantive discussion held in the CI and Organizations session.

Recommendation 1 – *Expand and develop research efforts on CI and Organizations:* Build the subfields of research on CI-enabled organizations and the organization of CI. We expect the primary focus to illuminate topics such as:

- How to study, support, and sustain CI-based organizations;
- What organizational frameworks and processes are most useful for the design, implementation, and upgrading of CI;
- The characteristics of organizations, communities, societies supported, enabled and created from CI. Communities of practice are examples of horizontal organization where control is in the ethos, professionalization, shared understanding, meaning, language and professional practices. CI requires understanding of organization across communities of practice; CI may be conceptualized in terms of communities of “communities of practice.”

To build a robust theoretical and empirical base, research on CI organization requires a range of investigations using a wide variety of research methods from ethnographic studies that develop “thick” description to formal modeling and simulations. The research program should draw from dominant methods across the range of social sciences.

Recommendation 2 -- *Tools and data management support:* Develop an enabling, useful and usable set of CI tools and data management support for enabling social science research and education.

The second recommendation focuses on useful and usable cyberinfrastructure tools for data management support for research and education. Session participants felt that there was a particular need for data-oriented tools and technologies. Specific areas included:

- Tools which better support, archive, preserve, manage social sciences databases and data collections
- Improved tools for observation, data analysis, mining, interoperability of data bases, data integration, privacy, confidentiality of data, etc.

Recommendation 3 -- *CI-savvy human capital:* Design and build programs, mechanisms and activities to attract, educate, and retain human resources to advance cyberinfrastructure research and practice needed to support CI.

The third recommendation focuses on the development of the research and leadership base needed to lead knowledge and action for CI. This recommendation carries within it the need to expand knowledge of organizational and social science issues in Cyberinfrastructure (including service and

implementation of CI). The session participants recommended programs, for example, to recruit and support predoctoral and postdoctoral fellows in specialized research areas and to influence professional recruitment and education in organization and cyberinfrastructure. Among the promising models that might be adapted or used to develop educational infrastructure are programs such as the “Transformational Research Experiences for Scientists” (TRES) and the Immersive Summer Workshop integrating a broad spectrum of social scientists, domain experts, technologists, and other stakeholders in CI.

Recommendation 4 – Organize the CISE-SBE Cyberinfrastructure Research Community: Develop a pro-active strategy and explicit formal support mechanisms for building an interdisciplinary, cross-sector community of practice at the interface of the SBE and CISE communities.

The fourth recommendation focuses on *community building*, not just for organizational researchers in SBE but more generally for the SBE-CISE interface community. It will be particularly important to involve users, stakeholders, cyberinfrastructure providers, students, postdoctoral researchers, and community practitioners from the start so that the scientific community can grow in a balanced and comprehensive fashion. Several suggestions were offered for how this community can be developed and nurtured including:

- An annual NSF “PI meeting” or “All-Hands Meeting” for PIs with CI efforts at the interface of SBE and CISE and interested others
- Development of standard academic and emerging community vehicles including a new professional society or interest group, a new journal, community blogs and wikis, and a new annual “Cyberinfrastructure and Society” conference
- Targeted conferences and workshops with the theme of “Cyberinfrastructure for *x*” where *x* is a key societal challenge such as community response, health, safety, etc.

V. What are 3 key research problems important to communities in your session?

The first research problem is fundamental to CI and to organizations: **What are the appropriate governance (coordination and control) structures that allow minimal but effective control of CI-enabled organizations and that do so in a way that does not subvert or thwart flexibility and innovation?** A related research question is: *What can CI teach us about new modes and forms of governance, coordination and control that are likely to become necessary as CI is built out in society?* Research is needed to identify, examine, and, where appropriate, disseminate radically different forms and processes of “governance” in virtual organizations and other new types of organizational forms. CI requires a combination of visible governance, management and administrative systems with invisible, non-intrusive sources of coherence and control embedded in systems design and internalized in norms, values, beliefs and practices.

The second research problem focuses on the processes of change and transformation required in the uptake and adaptation to cyberinfrastructure. **How are organizations changing to leverage CI?** This research problem requires examination of the properties, including outputs and outcomes, of organizations as a result of CI and their many processes including processes of transformation and change, business processes, supply chain processes, and communication and control processes. Research studies might identify and examine exemplars of CI to extract best practice and benchmarks for use in populations of organizations. CI is not self-organizing, therefore processes of development are a key area for research in order to minimize the costs of CI development and to maximize the potential gains from CI. Contemporary CI evolves over time and cannot be wholly designed; yet developmental processes can be carefully and systematically observed and, where possible, measured. One approach to thinking about models and frameworks is the parameterization of co-evolutionary processes. But it should be remembered that CI will be different in different contexts, e.g., big science v. emergency response.

The third major research problem focuses on: **How to develop useful data-oriented social science infrastructure at a level and scope needed for the next generation of discovery** and previously unavailable before the development of CI. Data-based social science and data-based policymaking at a scale made possible by CI are promising and important areas for CI and SBE research. Modest examples include the Indicators Project undertaken by the Boston Foundation to develop policy and planning capacity through large-scale, dynamic, systematic use of indicators; the Iowa Electronic Markets form a second example which is yielding a variety of insights into group decision making processes. More broadly, we envision a relationship between CI and SBE that will yield routine, automatic data collection, analysis and feedback for researchers, organizational participants, citizens, and other decision makers. These societal and research benefits should accrue as CI built for big science spills over into a range of social and policy science uses.

VI. What are 3 key technologies and their characteristics important for communities in your session?

The CI and Organizations section felt that better environments for collecting, interpreting, storing, and working with data formed a key focus for enabling technologies. Three particular focus areas of importance include

- Interoperability of data, observing systems, tools, technologies, resources (e.g. for nations, municipalities, settlement areas)
- Improved data management software and standards
- Tools for using transactional data in research

VII. Give at least one “moonshot” for your area -- a problem in your area that is immensely important and compelling, and will require the combination of SBE, CISE efforts and cyberinfrastructure to solve.

Moonshot 1: “CI to guard against societal threats” How do we create effective coordination and organizational frameworks which allow us to provide early warning systems to respond to societal threats -- disease epidemics (SARS, avian flu, etc.), extreme events (tsunamis, earthquakes, terrorism), etc.?

- *The technology is in reach, but the organization and coordination is critical to the effective use of the technology*

Moonshot 2: “CI to ensure U.S. competitiveness” Today’s organizational frameworks are not adequate for fostering the high levels of creativity, innovation, flexibility, and dynamic adaptability needed to ensure U.S. competitiveness and leadership. How do we use Cyberinfrastructure to exploit cutting edge communications and information technologies to build the “organizations of the future” required for globally competitive, leadership organizations? It follows logically that we will need to conduct research to help the nation develop the workforce, managers, executives, scientists and leaders who can most effectively design, lead and work in CI-enabled organizations as the new infrastructure for the economy and society.