From Loss to Gain: Exploiting Diaspora in Cyberinfrastructure Enterprises[1]

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Finding and holding on to good people is a challenge in cyberinfrastructure ("CI") enterprises,[2] where the relevant leading-edge skills are in great demand. Research-oriented CI enterprises that lose personnel to industry often see this as a failure of the system or of leadership to hold onto valuable employees. The departures are considered "lost to science," and must be replaced, often with difficulty and much expense to taxpayers who have paid for the expert's training. However, there are benefits to CI enterprises from the departure of key personnel. This departure can be characterized as a form of "diaspora" – one that has a beneficial side that is rarely articulated – much like emigrant diaspora from developing countries.

Emigrant diaspora from economically developing countries to developed countries have sometimes been viewed as net losses to their country of origin. But resulting diaspora networks have been found to contribute positively to developing nations by providing contacts, experience, and business for originating countries (Beine et al, 2001; Smart and Hsu, 2004, Kuznetsov, 2006). We draw on research into nine CI enterprises explore how diaspora associated with such organizations serve positive ends. This work characterizes different forms of diaspora and explores the mechanisms by which diaspora brings positive impacts.

Three broad forms of gain from diaspora are relevant to CI enterprises:

- ***Diaspora of Science-trained Personnel to Industry:*** People with leading edge skills expand the capabilities of the nation's private sector. They can provide both human capital and advanced technology for entrepreneurial ventures, contributing to regional economic development. The movement of such people can bring economic return to the science organization (e.g., the university), through active alumni- oriented activity.
- ***Diaspora of Science-trained Personnel to Other CI Enterprises***: Skilled employees of science-oriented CI enterprises sometimes go to other CI enterprises as leaders or to start new CI enterprises in other locations. This presents a challenge for the organization that loses the skills, but the net capabilities of the nation are enhanced.
- ***Diaspora as "Graduation" of Science-trained Users***: This form of diaspora is slightly different in that it focuses on users rather than employees. Science-oriented CI enterprises sometimes lose the users of their services to higher levels of service (for example, when a skilled user of a local compute cluster moves to become a user of a

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[2] "CI enterprises" refers to organizations charged with building advanced, and usually large-scale instrumentation and computation infrastructure for scientific activity. CI enterprises include high-performance computing centers, national labs, distributed disciplinary software ecosystems, long-term infrastructural software projects, and large-scale instrumentation, sensor, and monitoring organizations.

national-level supercomputing resource). This opens up capacity in their service and contributes to the portion of overall scientific activity at most advanced levels.

Diaspora can thus be seen as positive and constructive when seen from the human capital perspective of infrastructure (Lee et al 2006). Next-generation science is enabled by an infrastructure of software, systems, storage, and networking that is technically easy to see, but whose *human* elements are easy to miss. For example, the emerging occupational category of 'data scientist' is populated with people who came from careers in CI enterprise, where cyberinfrastructure had already brought major changes (Davenport and Patil, 2012). Their movement brought benefits in the form of increased national capabilities, workforce development, human infrastructure development, and alumni business development. These changes may represent loss of human capital to specific enterprises, but their diaspora is important to national competitiveness. Departing employees leave a gap that CI enterprises must fill through training, often increasing access by young talent and "forcing" training across generations. The attractive career paths of "graduates" bring talented individuals to CI enterprises, whereby they gain access to career advancement through the alumni network.

Science policy research shows human capital development is an important component of national and international innovation systems (Bozeman et al 2001; Bozeman and Mangematin, 2004). Science and technology training helps establish new businesses (Murray, 2004; Ding and Choi, 2011). Such characteristics accrue to CI enterprises as the diaspora of CI employees expands scientific capabilities and improves economic returns. This paper examines the impact of diaspora at different levels through which CI enterprises receive funding (*e.g.,* national funding agencies, state and local governments, universities, firms), and looks into the mechanisms through which diaspora generates value at these different levels (*e.g.,* the university, the region, and the nation).

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