Service Science, Management And Engineering: A Way of Managing Sociotechnical Systems

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ABSTRACT

This paper discusses an expanded notion of services, ones that can lead to the transformation of systems in ways that are beneficial for business, engineering and society—because all of these are parts of a larger system. But what I say here also applies, on a reduced level, to systems problems that are apparently more local, like modeling and responding to a changing business environment in a specific market and area.

Introduction

I would like to discuss an expanded notion of services, ones that can lead to the transformation of systems in ways that are beneficial for business, engineering and society—because all of these are parts of a larger system. But what I say here also applies, on a reduced level, to systems problems that are apparently more local, like modeling and responding to a changing business environment in a specific market and area. The smaller problem is a sub-set of the larger one. I will use a framework for interdisciplinary collaboration highlighted at a recent workshop on "Trading Zones and Interactional Expertise".[1]

Earth Systems Engineering Management

To begin, let us consider an example from environmental systems management.

Brad Allenby has called for an Earth Systems Engineering and Management (ESEM) capability to manage the global eco-system where human beings, nature and technology are closely coupled in a complex, dynamic network [1]. Every part of the globe is now affected by human activity; therefore, our species has a responsibility to monitor and manage our interactions. Because the global ecosystem is complex and dynamic, new technologies and policies will have unintended consequences. Therefore, continuous monitoring and adaptive management are required. Furthermore, perturbations in this system will affect a wide range of stakeholders; therefore, constant dialogue is also required.

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[1] http://bart.tcc.virginia.edu/Tradzoneworkshop/index.htm

Smaller, apparently more local environmental problems can no longer be considered in isolation. Management of the Everglades, for example, will be affected by global warming, which could bury much of this delicately-balanced system under salt water. Furthermore, optimizing management at the local level may have unintended global consequences. Prohibiting logging in one part of the planet may simply increase logging in others—unless the prohibition is accompanied by measures to reduce global demand or develop appropriate substitutes.

The growing service sector of the global economy [16] poses a similar set of problems. Changes in one part of this growing global network may have unanticipated ripple effects in others. Allenby proposes developing an ESEM expertise to facilitate management of the global ecosystem. Similarly, managing the service economy requires a new kind of expertise.

SSME, like ESEM, involves combining multiple disciplines to form a new specialty that increases our ability to manage the way in which we are transforming the sociotechnical systems we inhabit. Interdisciplinary efforts lead to generalists that after some time become specialists in a new domain [16]. Computer science, for example, combined software and algorithm complexity theory, as well as hardware and logic design, into a new specialty that increases our understanding of computation in technological systems. Ultimately, this deeper understanding of service system evolution could lead to more systematic approaches to service innovation. Service innovations have the potential to impact service productivity, service quality, and rates of growth and return for service systems.

The service scientist as an interactional expert

Two sociologists of science [5] have described three levels of shared expertise in socio-technical networks:

None: Here experts in different disciplines 'throw solutions over the wall' to each other. There is no effort to share knowledge, or understand the other experts' mental model. For example, designers of a technological system can make no effort to understand the user's mental models [11]. In other cases, the user community may have no readily identifiable formal expertise, but still possess important knowledge. Consider those suffering from AIDs who did not want to be in the placebo groups for testing new AIDs treatments. Members of this community decided to learn as much as they could about research protocols, so they could modify them.

Interactional: These AIDS activists gradually acquired enough expertise to be able to discuss research strategies with members of the medical research communities. Eventually, they were able to make contributions to the design of research studies, based in part of their knowledge of how their community would get around protocols by buying street versions of the drugs being tested. [6]. Collins and Evans use the term 'interactional' to refer to the ability to interact intelligibly with members of more than one expertise community, facilitating knowledge exchanges [5].

Contributory: This kind of shared expertise involves experts who learn enough about other disciplines to make original contributions. The physicist Luis Alvarez, working with his son Walter, a geologist, was able to make a significant contribution to paleontology by discovering a geological level corresponding to the Cretaceous that contained thirty times more iridium than the layers above and below it. Based on this and other evidence, the Alvarezes proposed that a meteor collision with Earth accounted for the extinction of the dinosaurs [2, 17].

The service scientist will have an expertise of her or his own, but may also have to become an interactional expert. The service scientist cannot master all domains of knowledge relevant to a societal and/or client problem; instead, she or he needs to be able to interact intelligently with expertise communities whose knowledge bears on a pressing problem. The challenge of getting a diverse population of scientists to speak a common language around "service innovation" will also require training at least some of them to be able to converse across disciplinary cultures. Such training will be facilitated by exposure to case-studies from the cutting edge of services business. As the number of different disciplines required for state-of-the-art service innovation expands, so will the need for interactional experts who can bridge the disciplinary cultures.

To be successful, the SSME expert, other experts, clients and other stakeholders involved in a problem or opportunity will have to create an effective trading zone.

Trading Zones

Peter Galison used the metaphor of a trading zone to explain how scientists and engineers from distinct disciplinary cultures manage to collaborate on the design of new technologies [7]. He studied the development of radar and particle accelerators and found that different expertise communities had to develop first jargons, then pidgins, and finally full-scale creoles to get around linguistic and conceptual barriers. The key to Galison's approach is that it is possible for communication to take place locally even when they disagree about "global" meanings: "They can come to a consensus about the procedure of exchange, about the mechanisms to determine when goods are 'equal' to one another. They can even both understand that the continuation of the exchange is a prerequisite to the survival of the larger community of which they are part" (p. 803).

In NSF workshops developing new interdisciplinary initiatives, "One of the most striking features of the workshop process is the amount of reciprocal adjustment required to get all participants, from within NSF and without, talking about the same topics in a mutually comprehensible language" [10, p. 254]. These workshops are trading zones, where the participants are funded to work together but need to adopt at least a common pidgin, and also the development of metaphors that can " help groups of people from disparate backgrounds think about a problem in the same way" [13, p. 12.]

For example, in a workshop Gorman conducted on scientific and technological thinking [9], spanning disciplines such as psychology, cognitive science, philosophy, history and sociology, the pidgin consisted of agreeing on meaning for certain terms like problem space and mental model, The workshop also adopted two primary metaphors: shared toothbrushes and spherical horses. The former referred to the perception that most scholars liked to share frameworks about as much as they liked to share toothbrushes. The latter referred to a joke about a physicist who said he could predict the winner of any horse race to multiple decimal points—provided it was a spherical horse moving through a vacuum. These metaphors emerged early in the workshop and kept the participants aware of the importance of developing a shared framework (not a toothbrush) and conducting research that was relevant to science and engineering practice (not just spherical horses). By the end of the meeting, all a participant had to say was 'shared toothbrush' or 'spherical horse' and everyone else in the room knew what was implied.

Service scientists as agents in trading zones

Early in the development of MRI, surgeons interpreted as a lesion what an engineer would have recognized as an artifact of the way the device was being used, This breakdown in the creole between these communities was recognized and solved by an interactional expert who had a background in both physics and medicine [3]. This case study suggests that interactional experts can serve a function similar to agents or brokers, mastering enough of the language and metaphors of different communities of practice to facilitate trades. For example, agents of the Hudson's Bay Company worked the interface between two kinds of civilization, European and Native American [12]; similarly, service scientists will work on the boundaries between multiple communities of practice [4].

The service scientist could serve as this kind of interactional agent in trading zones, facilitating exchanges of knowledge and resources across different communities of practice. The service scientist might work for a company, offering adaptive solutions to a variety of problems. Or she might be a consultant, working with clients. The service scientist would be capable of visualizing and monitoring the impacts of solutions on the socio-technical system, at both local and global levels.

Consider telework: a suite of technologies for facilitating trading zones over a distance, cutting-down on the need for commuting and flying, saving hours and reducing greenhouse gases. But face-to-face contact is still important in gaining trust, including the ritual aspects of 'breaking bread together' and sharing experiences outside of work. To adopt telework, human practices have to change along with the technology. A service scientist attempting to implement such a solution would have to look at the impact on the local system, in terms of work patterns, distributed physical space, what activities and persons require face-to-face communications, synchronous and/or asynchronous. She would also have to consider environmental benefits and potential harms, as seen from the perspective of multiple stakeholders. What would happen if multiple organizations adopted a similar telework strategy? Would this undermine existing communities? Create new ones?

SSME as Transformative

The word service implies that SSME will serve the needs of clients, giving them what they want. In fact, SSME requires what Systems Engineers refer to as outscoping, or determining what a client really needs—which may be different from what they say they want [8]. Service Scientists need to be looking ahead, imagining the way in which techno-social coevolution will transform systems on a variety of levels [16]. At least some Service Scientists should be outscoping on a global level, facilitating the development of systems that will raise the standard of affluence, enable increased transparency, and improve the environment.

Every service scientists will end up being a reflective practitioner [14], seeing not just the system but also her part in it. Cognitive diaries are a good tool for this kind of reflection [15]. Service scientists will need training in a core discipline, like computer science, or cognitive science, or environmental science or medicine, or law, depending on the type of systems they intend to specialize in—though the boundaries between systems are fuzzy at best, and do not correspond to traditional disciplines. The interactional component will require every service scientist to gain skills in facilitating and managing trading zones, a new kind of competence that will draw on disciplines like anthropology and social psychology, but move beyond what is currently known. Inevitably, such training will have an experiential component, in which service scientists serve as apprentices to those more experienced, learning and reflecting.

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