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The Practice of e-Science and e-Social Science

Method, Theory, and Matter

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Abstract. Grid technologies are widely regarded as important innovations for drawing together distributed knowledge workers into virtual communities. After reviewing the developments in e-science, we examine the emergence of e-social science and the potential impact on scientific discovery. Grids are currently in a key developmental phase during which the field of information systems can bring significant insight. We consider what is new about the Grid phenomena and discuss the issues raised by this particular approach to the virtualization of research practices. Our analysis is organized into three sub-sections that focus on: developments in e-social science research methods; the theoretical issues involved in pursuing an e-social science agenda; as well as the status and nature of the research materials that it gives rise to in information systems.

1 Introduction

While we are quick to study different kinds of virtual work and virtualization in distinct contexts [1], it is easy to overlook our own work practices as scientific researchers (notable exceptions include [2,3]). The pervasive use of information and communication technologies has enabled new forms of knowledge work of which research is a fundamental example. We should therefore debate the impact of ICTs on our ways of working just as vigorously as we debate organizational changes in other professional contexts. Within the sciences and humanities there is a current interest in what has become termed e-science and e-social science, whereby distributed information technology infrastructure is employed to support collaborative research practices. This area is likely to be of considerable interest to those in information systems who have been studying the related topics of collaboratories [4], the use of the Internet by scientists [5], and infrastructure [2].

Is this a new era for social science research method or just an expansion of bandwidth and another instance of the small case letter "e" being put in front of something we already know about? In this paper we discuss the practice of e-science and e-social science in order to consider the insights that the field of information systems can bring to bear on what is a key developmental phase of its emergence. We begin by defining the terms used in the paper and then turn to a discussion about the implication of these technical advances for our methods, the theory that we use to understand them, and their design.

This paper explores the dynamic relationship between method, theory and matter as a means of surfacing their mutual implication. Working from the principle that method cannot be axiomatically neutral, the purpose of our investigation is to raise awareness regarding the theoretical assumptions shaping emerging methods of research and the implications that this has for investment in the standards inscribed into major research infrastructures. In sum, if we acknowledge that neither technology nor method is neutral, then surely the way that they are combined into a research infrastructure matters?

1.1 The Development of e-Science

"e-science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it."[1] It emerged from the realization that many areas of science were becoming increasingly reliant on new collaborative, multidisciplinary working [6]. In particular e-science centres upon the use of an innovative, powerful computer-based infrastructure called 'Grids' within natural science with the aim of constructing a "cyberinfrastructure" for research collaboration (see www.escience-grid.org.uk and www.globus.org). This endeavor has been defined as the "*intersection* of Grid and collaborative research" [7,original emphasis]. While e-science is not a coherent endeavor and is associated with much rhetoric [8], it can be characterized by scientific mega-projects carried out through distributed global collaborations enabled by Internet technology, very large data collections, massive computing resources, and high performance visualization methods (see www.rcuk.ac.uk/e.science).

Grids predate their association with e-science. The original designers of Grid infrastructure, Ian Foster and Carl Kessleman [9], define Grids as an enabler for Virtual Organizations. They were developed to overcome limitations of IT resources (CPU cycles, disk storage, software programmes, and peripherals) within one

[1] Definition by John Taylor, Director General of Research Councils, Office of Science an Technology. Quoted from http://www.nesc.ac.uk/nesc/define.html. Retrieved 16th February 2007. See also [6].

location by pooling these resources through network connections, in particular the Internet. In other words, the resources can be shared beyond their local domain with a distributed 'Virtual Organisation'. The term Grid was chosen to denote the ability to access computer resources on-demand in a similar way to how electricity is accessed using the power utilities grid. The technological governance of a Grid is managed through its middleware, which represents a formal point of compliance between the Grid context and the application with which the researcher works. The management and use of such a Grid is necessarily collaborative. "Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualisation back to the individual user scientists. (Research Councils UK)[2]

The natural sciences (such as particle physics) have a tradition of team-based projects and are often cited as an example of distributed knowledge work [10]. Globally distributed collaboration is prevalent within fields such as particle physics, as is the use of networked computing technology (indeed the World Wide Web was initially developed by and for this community) [8]. It is therefore perhaps unsurprising that these fields provide leading examples of e-science research mediated through Grids. For example the experimental particle physics community pioneered the development of global grids for its research at CERN, and are currently being studied by researchers in the information systems field [11] (see http://pegasus.lse.ac.uk).

The use of Grids, within the natural sciences, presents significant challenges, some of which are well documented, some of which are novel and relate to the particular manifestation of Grid technology with which they are engaged. Within experimental particle physics and astro-physics, grids are employed for extremely large-scale data distribution and storage (www.gridpp.ac.uk & www.astrogrid.org) presenting problems with the storage and network capacity required. Microelectronics groups are employing e-science as a way of approaching the challenges of semiconductor design within which concerns for licensing of software designs and the protection of the intellectual property rights are paramount.[3] Communities such as Biotechnology and Medicine are concerned with the integration of large data sets for analysis and visualisation [12]. Since these fields employ animal experimentation data and patient records they are particularly concerned with privacy and access control (http://www.brc.dcs.gla.ac.uk/projects/bridges/) [13]. In addition to the use of technology, e-science demands collaborative practices among scientists. The Virtual Organisations that are central to Grids "enable disparate groups of organisations and/or individuals to share resources in a controlled fashion, so that members may collaborate to achieve a shared goal" [14]. Such virtual organisations require trust and new approaches to justifying scientific discovery [15]. Within the natural sciences increasingly collaborative research has demanded new forms of organization [16] that become reflected in a Grid's Virtual Organization.

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[2] http://www.nesc.ac.uk/nesc/define.html Retrieved February 2007.
[3] http://labserv.nesc.gla.ac.uk/projects/nanoCMOS/index.html

Within e-science there are projects whose research agenda overlaps with familiar Information Systems concerns. The VOTES project[4] for example is concerned with the clinical trials and epidemiological studies and focuses on issues the Information Systems community may recognize such as patient recruitment, data collection, and the study management of clinical trials. Finally within the e-science community there is a broad concern for the usability of Grids, evidenced by a UK funding council's call for research in this area [17,18]. Although many scientists are comfortable with employing advanced technologies in their research, Grid technology currently requires technical expertise that is not particularly usable. This concern is of crucial importance within e-Social Science where researchers' experiences with advanced and prototype technologies like Grid's is very limited.

1.2 The Emergence of e-Social Science

e-Social science[5] focuses on the adaptation of Grid technologies and tools that have typically been applied in natural science to advance the social sciences. It is important that we consider the differences between e-science and e-social science [15]; whereas natural science is pre-dominantly team based, social science centers on individual effort and can have a strongly interpretive character. The UK's National e-Science Centre notes that before Grid technologies can be widely accepted by the broader social science community, "there are significant obstacles to be overcome. These relate to such issues as the commodification of Grid technologies, the shaping of national infrastructures, and organizational contexts as well as developments in research traditions." (www.nesc.ac.uk/esi/themes/theme_03)

There are pockets of researchers working on these issues around the world pioneering Grid technologies. The tools that they are developing could prove highly relevant for scholars in the field of information systems particularly those interested in exploring research topics that are multi-dimensional, for example data from Blackberries or mobile phones that raise issues of timing and spacing (see "Replayer" in [20] and "SHAKRA" in [21]). Other examples of large data sets that can be gathered might include: activity and/or usage data, multi-channel working (for example, Instant Messaging), audio data from call centres, geographical information systems data on identity card use, or the digital forensics of money laundering.

In addition to the topic-dependent features of data that can be explored, there is a broader range of media that can be stored. There is a new generation of cinematic narratives that can be dynamic and move in time/space; these include wearable ICT and use of mobile networks combined with GPS as well as other sensing technologies. Researchers will have the opportunity to reconfigure the traditional research dynamic by asking research participants to keep their own video/audio

[4] http://labserv.nesc.gla.ac.uk/projects/votes/index.html

[5] [19] notes that some people find the distinction between e-science and e-social science an artificial distinction and would prefer a non-English term like "e-Wissenschaft" to overcome this.

journal entries, fill in PDA activity logs in their own time/place, and/or participate in two-way communication at-a-distance. Information systems researchers will surely be interested in the development of Grid-enabled distributed work practices themselves (see [22] for an example of using Wikis in collaborative ethnography). It is notable that many key figures that have shaped the literature on Computer Supported Cooperative Workgroups (CSCW) and Virtual Organizations (VO) have turned their attention to Grid technologies (Judith and Gary Olson's interest in the idea of "collaboratories" http://www.crew.umich.edu/index.html). In the next section, we consider the implications of e-social science on research methods in more detail.

2 Method

As automation increases and technological costs fall, the opportunities for curation of digital data expand. Organizations dedicated to the acquisition, dissemination, and re-use of qualitative social science research data are emerging (for example, http://www.esds.ac.uk/qualidata/online). Digital curation refers not only to the maintenance of a trusted body of digital data for current and future use, but also involves exploring ways to add value to it (see www.dcc.ac.uk). There are significant challenges associated with combining information from diverse and distributed data sources; the number, complexity, and diversity can be daunting. A recent issue of Information, Technology and People explores the different genres of digital documents (see [23]). Preparing the original material for current use by colleagues distributed around the Grid or for digital curation sometimes places a considerable burden on the field worker or data set owner who must conform to set standards in, for example, transcription or format.

A considerable effort has been put into the development of non-proprietary formats and standards for preserving, searching, and disseminating data (see The Edwardians project at ESDS above). This kind of interoperability is fundamental to the portability and data interchange that underpins the intention of Grid approaches (see http://www.esds.ac.uk/qualidata/online/about/xmlapplication.asp#ten for a draft DTD (document type definition) for a generalised XML qualitative dataset application).

Large scale computing resources provide opportunities for massive data storage and archiving of multiple digital resources (text, video, image, audio), that can enable hyper-ethnographies using video storyboards or video paperbuilders (http://vpb.concord.org). These sensory-rich media forms challenge our current research methods and represent the frontier of pedagogy [24] as well as forming living histories of research practice. However, this only represents a partial realisation of Grid potential. There is capacity for increasingly interactive and dynamic forms of research approach that move beyond catalogue searching and data download to allow web-based free-text and filtered searching, browsing, and retrieval of research data in real time.

Access to archives of qualitative data also presents the opportunity to pursue innovative case study strategies that move beyond snapshot survey methods and transform multiple case research from the preserve of project-based initiatives (or long research careers) into the realm of possibility for individual researchers and doctoral students. Grid technologies could support the further development of social network analysis as well as stimulating a greater variety of qualitative-quantitative methods of data analysis (see [20]). The question of which research methods are more suited to the Grid environment is a contentious one.

For example, the notion of e-social science raises potentially uncomfortable questions for the information systems interpretive research community. In the past, interpretive researchers expended much intellectual energy explicating the differences in their work for the benefit of 'hostiles'. Interpretive research now has a much broader acceptance in the information systems community and is in a phase of constructively examining the interpretive form rather than defending it. Intepretivism is a "set of epistemological assumptions" [25] but whilst we have guidelines for good practice [26] and we follow recognised qualitative research protocols there is still a high level of flexibility in the execution of interpretive practice. The epistemological assumptions that Orlikowski and Baroudi refer to serve both as a broad set of co-ordinates with which the researcher can mark the beginning of an intellectual journey and they steer us in the general direction of inquiry [27]. In the process of appropriating these broad assumptions researchers must interrogate and give meaning to them, for they are not neutral axiomatic principles. Each person's interpretation of the assumptions underlying their research approach will have consequences; it will give them eyes to see certain topics or questions and not others; it will influence the way that their research approach becomes enacted in practice; and it will influence the status and nature of any contribution that they make.

It could be argued that e-social science lends itself more readily to positivist methodological techniques in which researchers aim to triangulate findings with the aim of finding commonalities and scoping out inconsistencies in the data set. In contrast, an interpretive researcher with strong constructivist leanings might build upon contradictions in the data to reveal political narrative and may resist the notion of reducing interviews to codes as the basis for content analysis. Indeed, many established interpretive researchers balk at the suggestion by reviewers that they should explicate formal processes of analysis preferring to stand firmly by the conviction that their findings emerge solely from knowledge of the field arrived at through reflection, insights, and intuitive induction.

This exhumes some tired controversies that have dogged interpretivism, namely lack of critical purchase, its tendency toward relativism, solipsism and over-privileging the inquirer's perspective, the confusion between the psychological/epistemological, and finally, the paradox of how to develop an objective interpretive science of subjective human experience [27]. The creative infusion and adaptation of information systems research methodologies, such as interpretivism, into the e-social science offers opportunities for new forms of rigor and relevance (see the debate in MISQ 1999 23:1). One would hope that there are those among the interpretive IS community that possess a strong will to innovate and experiment, but large scale research practice does present distinctive issues that would be hard to overcome. While it is for each researcher to take their own position on this, it is conceivable that interpretive IS researchers will largely avoid e-social science.

At the IFIP 8.2 working group conference in Manchester [28], senior figures in the IS field called for more extensive use of multi-disciplinary research, and it is possible that a team approach might represent a fruitful possibility for different genres of researchers to engage in e-social science. As we have noted, social science research tends to be a fundamentally individual endeavour. However, there are compelling grounds to consider revising this norm to accommodate other practices. Dennis et al. [29] point out that the IS field "publish elite journal articles at a lower rate than Accounting, yet our promotion and tenure standards are higher" creating a "growing divergence between research performance and research standards." These pressures reduce the quality of work-life experience and job satisfaction for junior colleagues and lead to "increasing faculty turnover, declining influence on university affairs, and lower research productivity" [29]. One way of addressing the issue of research productivity is to explore the teamwork opportunities offered by e-social science. This would require support from established senior researchers to mitigate the risks of such an experiment for those already wrestling with the intensity that now accompanies junior academic careers. Of course, multiple author publications also have to form part of a balanced portfolio alongside single authored articles; however the interaction with a distributed community and teamwork could help overcome the sense of isolation that can accompany individual efforts to produce elite publications.

3 Theory

In this sub-section, we return to the theoretical implications surrounding the development of e-social science. At a session of the 2006 National Centre for e-Social Science (NCeSS) conference, after the presentation of a software tool designed to support the analysis of mobile technologies, a member of the academic audience commented "That's great, but where is the social theory? Where is the e-social science in your approach?" Are Grid technologies about organizing, storing, filing, communicating, and accommodating ICTs into research methods or is there a theoretical question?

From our perspective, the comment made by this conference delegate does not so much set a new design agenda for those developing this software or call for us to develop a theory of e-social science, it poses a challenge with regard to the articulation of the relationship between theory and practice. The social science oriented software-based tools being developed for Grid contexts are not being designed to provide explanation and prediction, they represent a distinctive way of gathering and organizing data. However, we wish to pause here to clarify what might perhaps seem an otherwise common sense observation. Our position is that data are a fundamental part of research practice and as part of the pattern of our work are fundamentally social, expressing (or imbued with) a relationship to theory because that is part of our research practice. This brings us to a reflection on the practice of research and a consideration of whether there is theory in our actions. The study of practices has received considerable attention, including a special issue of the *Information Society* in 2005, and of *Organizational Studies* in 2006 which we draw on briefly to explicate our position on the notion of e-social science research practice.

Following Reckwitz, we define practice as “a routinized way in which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood” [30]. When we engage with data we are, as Reckwitz says “using particular things in a certain way” and when technologies mediate that use it necessarily shapes practice; they enable and limit “certain bodily and mental activities, certain knowledge and understanding as elements of practices” [30, pp. 252-3].

When social scientists discuss Grid and Grid-focused tools as a context for their work (despite the long discourse in our field on social shaping of technologies) they are drawn into modes of discourse in which it is presented as a sanitary, neutral environment over which they will lay their research practices. As Orlikowski [31] says, it is important to understand both the technological artifact and the technology-in-practice; both have significant implications for understanding developments in research practice. For example, there is regular reference to ‘raw data’ in the material on e-social science, a notion with which we have taken particular issue. When software products gather data they do so under a number of presuppositions or assumptions encoded in their design, function, and use. It is, for example, extremely unlikely that two e-social science software programmes would select the same data, a simple yet powerful test of this point. Returning to Orlikowski’s [31] idea of “in-practice” and “in-use,” our point is that it is important to reflect upon the notion of “data-in-practice” and “data-in-use.”

Kuhn's [32] analysis of paradigms in scientific inquiry taught us “scientific communities are bound together by conventions and commitments that build upon taken-for-granted assumptions.” The development and use of particular research methods can be associated with identifiable groups of scholars or what Wenger calls “communities of practice” [33]. As Kelly and Jones [34] note, much of the communities of practice literature emphasises the notion of communities rather than practice. If we take the proposition that theory is expressed through in our practices seriously then we begin to see how particular research identities could colonise and shape the emergence of Grid technologies and the standards embedded in its infrastructure. Following this through, we also need to draw together a body of research that deconstructs the largely taken-for-granted term of “information infrastructure” [35] and assemble detailed analyses focusing on the emergence of specific infrastructures to support particular research practices. This includes understanding the role of agents of change that move between groups diffusing ideas, working toward the articulation of standards, and encouraging “convergence” [35, p. 82]. How do norms emerge in e-social science? How and where does the structuration and institutionalization of specific research practices take place? In the next sub-section, we consider the conceptual and material structuring of research in more detail.

4 Matter

The development of e-social science is in an interesting definitional phase where its design parameters are relatively open. As dominant research groups emerge we may see the black boxing of both the material basis of the Grid design and the conceptual expression of research methods. Ackoff [36] maintained that the complex phenomena tackled by social science can often seem like “messes.” While “assumptions make messes researchable” it is often “at the cost of great over-simplification, and in a way that is highly problematic” [37, p. 377]. Our experience as information systems researchers should put us in a position to acknowledge that on the one hand establishing standards enables interoperability that helps us to built community infrastructures that link up knowledge workers over time and space. However, embedding assumptions about method into research tools designed to enable collaboration creates a new messy problem.

Burrell & Morgan [38] encourage us to analyze and challenge assumptions through map-making activities designed to increase awareness of taken-for-granted assumptions that shape social research. We suggest that Grid technologies enable methods whose assumptions need to be deconstructed in order to understand their relationship to methodology and the design of a research strategy.

Building on this, Gareth Morgan, in *Beyond Method* [37], argues that we need to go beyond a focus on technical methods to reveal the assumptions shaping research:

> A knowledge of technique needs to be complemented by an appreciation of the nature of research as a distinctly human process through which researchers *make* knowledge. Such appreciation stands in contrast to the more common view of research as a neutral, technical process through which researchers simply reveal or discover knowledge [37, p. 377].

In light of this, how far can we draw together groups of researchers and share methods in the way that natural scientists try to do? If we put our best effort into designing these research infrastructures to accommodate many different approaches to research and champion pluralism, how do we achieve the scale required to realize the distinctive opportunities that e-social science presents? On the other hand, if we announce the use of standards and common approaches, what do we lose in the process? Who will become advocates for particular e-social science research strategies, and on what grounds will they claim that we should prefer their approach over others? How will the increased use of ICT in research method shape claims regarding rigour? These are foundational issues and it is important for us to deliberate upon them if we are to seize the possibility of advancing research practice.

5 Conclusion

At this stage in its development, the emergence of e-social science raises many questions for the nature of distributed knowledge work of which research is a key part. As information systems researchers we are uniquely well positioned to interrogate the design of Grid technologies, their virtual organization, and their use, building on a rich research tradition in related areas (Jonathan Grudin [39] presented a seminal paper at a conference in Portland, Oregon, in 1988 examining why collaborative technologies for diverse distributed groups fail and the problems associated with the design and evaluation of CSCW). Grid technologies must overcome adoption and use issues associated with all innovation processes and sustainable applications need to be developed (see www.gridappliance.org). As e-social science tools and methods emerge, we suggest they should be accompanied by the development of forms of evaluation and points of access that render the assumptions underpinning these systems available for critique.

The standards and shared approaches implicit in engaging with e-social science enable the exciting prospect of conducting large scale research in ways not possible before. However, we need to move toward the establishment of research standards and shared e-social science infrastructures with informed awareness of the social shaping process [19] in which they are involved. The potential for a Grid elite or methodological hegemony to emerge should be regularly monitored, and those involved in the developments taking place need to be reflexive about design issues. An important aspect of this is an understanding of the nature of data as well as an appreciation of the relationships between method, theory, and practice. Our interpretation of these relationships matters and will shape research outcomes.

Grid technologies should not be thought of just in narrow terms as the preserve of quantitative or positivistic research. Advances in qualitative and interpretive traditions need to consciously attempt to converge with Grid developments to take advantage of this window of opportunity. Finally, we need to ensure that we don't fall into the trap of fetishising technology and instead remember to nurture the distinctive contributions that come from unconventional, non-standard innovation and openness to diversity of research approaches.

In this paper we focus on e-science and e-social science as a particular instantiation of virtuality with the aim of surfacing questions regarding their future by relating them to the Information Systems literature. We draw attention to the major epistemological influences currently framing e-science, and identify the social constructivist challenges involved in adopting it. Given the potentially major impact that e-science may have on scientific discovery we suggest that the field of information systems needs to become actively engaged in longitudinal studies focusing on the "project of e-science" and its social shaping.

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