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The Multi-Disciplinary Development of Collaborative Grids: The Social Shaping of a Grid for Healthcare

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THE MULTI-DISCIPLINARY DEVELOPMENT OF COLLABORATIVE GRIDS: THE SOCIAL SHAPING OF A GRID FOR HEALTHCARE

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Abstract

Grid computing promises a range of industries the ability to distribute and share computing resources "on tap" and to provide transparent communication and collaboration between groups and across borders. Yet developing and implementing such complex and interrelated technology requires collaborative working among a range of disciplinary groups and organisations. Within this paper we present a case study of the development of HealthscanGrid within the medical community. The HealthscanGrid project aims to deploy a European database of mammograms by using the Grid to facilitate collaboration and communication between clinicians across the EU. The case study, through the lens of social constructionism, is explored in an attempt to surface the way such systems are developed as a collaboration among multi-disciplinary groups and how such collaboration shapes the nature of the technology deployed. We present this debate, in the context of debates within management studies literature on the nature of multi- and inter-disciplinary research project. The paper concludes by reflecting on the role of Grids "Virtual Organizations" in the debate over relevance of Grids to practice.

1 INTRODUCTION

Grid technology aims to provide a transparent, seamless and dynamic delivery of computing and data resources when needed, similar to the electricity power Grid (Chetty & Buyya, 2002; Smarr, 2004), and in this way enable the sharing of computer processing power, storage space and information on a global scale (Berman *et al*., 2003). In a recent article Carr (2005) suggests that the shift to Grid computing forms of technology will "overturn strategic and operating assumptions, alter industrial economics, upset markets and pose daunting challenges for every user and vendor". Similarly Berman *et al* (2003) suggest that Grid infrastructure "will provide the electronic foundation for a global society in business, government, research, science and entertainment". And yet the reality of Grid technology is far from such prophecies optimism (or indeed pessimism!). While pilot projects are underway to develop Grids for a variety of uses within a range of scientific and industrial domains (Foster et al., 2001; Wladawsky-Berger, 2004) recent research suggests that it is politics rather than technology which may inhibit the success of many such initiatives (Orzech, 2003). This perhaps comes as little surprise to an information systems audience well versed in difficulties of developing and implementing integrated socio-technical systems. While we may aspire to create Grids which, like the power Grid, are (relatively) politically inert, the creation of such standardised infrastructure is a complex negotiation by the various relevant social groups involved (Hanseth & Monteiro, 1998). Technologies embody their developers' and users' social, political, physiological, and professional commitments, skills, prejudices, possibilities and constraints. Hence, Grids are not a static thing, but rather a collection of meanings that are contested by different groups (Bijker, 1995).

Through a case study of a Grid development project within Medical Imaging (HealthscanGrid[1]), we argue here that if Grids are indeed to support collaborative working practices mediated by ICT on a global scale (Foster et al., 2001) then there must be a greater appreciation of the social and political context of such

[1] All names have been anonymised.

infrastructures' development and use. Indeed those funding Grid research projects have increasingly focused on ensuring the relevance of research by mandating wider industry and user involvement[2]. This reflects a wider debate within management studies literature which suggest the need for research relevance and advocates industry involvement in research activity in order to bridge this "relevance gap", and suggested to be achieved through trans-disciplinary research collaborations (Foster et al., 2001; Starkey & Madan, 2001). Since HealthscanGrid, like many current Grid development projects, is multi-disciplinary, inter-organisational and centred around research contribution as well as development activity (Venters & Cornford, 2006), we draw upon such debates regarding the difficulties of multi-disciplinary research collaboration (Porac *et al.*, 2004; Mitev & Venters, 2007) and university-industry relationships (Inzelt, 2004) in order to explore the tensions among relevant social groups within the HealthscanGrid research project. The theoretical framework for such an exploration is drawn from social constructionism so enabling the paper to explore HealthscanGrid's development as a series of negotiations by relevant social groups.

The next section of the paper reviews the literature on Grids, information infrastructures development, and on multi-disciplinary research activity. This is followed by a description of the theoretical framework and methodology employed. The case study then follows, after which analysis is presented. The paper finally presents tentative conclusions for the information systems development and Grid communities.

2 LITERATURE REVIEW

The Grid is often seen as an emerging platform for coordinated resource sharing and problem solving on a global scale for data-intensive and compute-intensive applications (Foster et al., 2001). It is a practical solution to the problems of storing, distributing and processing the large amounts of data that will be produced by industry and scientific communities over the next decade. Grids are centered around a set of standards (protocols) for the control of distributed resources which are realized as Grid middleware software. Just as Internet protocols enable the sharing and integration of information on the Web, so Grid protocols aim to allow the integration of not just information, but sensors, applications, data-storage, computer processors and most other IT resources (Wladawsky-Berger, 2004). One of the central ideas within Grid computing is the "Virtual Organisation", defined in terms of collaborators and organisations, in order to enable such sharing of geographically distributed resources. Virtual Organisations define clearly what is shared, who is allowed to share, and the conditions under which such sharing occurs (Foster et al., 2001) and are encoded as rules within the Grid's infrastructure. Virtual Organisations thus "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" (Foster et al., 2001). Grids are becoming more and more central to the undertaking of advanced science such as particle physics (Venters & Cornford, 2006), social science (Scott & Venters, 2007) and in areas such as financial services, engineering and health. Smarr (2004) argues that the potential social consequences posed by Grids will have the same effect as railroads, and that people are not sociologically ready to deal with this speed of change.

We do not consider Grid development and adoption as merely technical components requiring implementation, but rather as integrated socio-technical achievements similar to information infrastructures (Hanseth & Monteiro, 1998). Information infrastructures are the mixture of the complexity of the information systems used in an organization and the organization's practices and routines within which they are situated (Cordella, 2006). They are socio-technical networks (Hanseth & Monteiro, 1998) established through complex socio-technical processes and shaped by events, circumstances, and unpredictable courses of action (Broadbent & Weill, 1999; Cordella, 2006). Such infrastructures are the

[2] See http://www.rcuk.ac.uk/escience/default.htm for details of the UK's research focus in e-science. EU Framework 7 funding will also focus on multi-disciplinary activity within its e-science programmes: See http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52005PC0119(02):EN:HTML.

output of the recursive dynamic interaction between technologies and people (ibid) and are designed as an extension and improvement of an already existing installed base of infrastructure (Hanseth, 1996). The installed base affects the possible paths of design and development of the new elements, and therefore becomes self-reinforcing. Yet Grids are perhaps more than an information infrastructure which becomes transparent in use and only become visible upon breakdown (ibid). Grids have a tendency to have a strong architectural form embedded within, and shaping, their Virtual Organisations. This reflects their potential use and does not simply extend or improve existing infrastructure, but enables a re-scaling of such infrastructure in order that new forms of practice may be enabled.

Building successful Grid for science is suggested to be one of the most challenging efforts for the science and technology community today since it must be undertaken cooperatively, as a community effort (Berman *et al*., 2003). Within the field of management studies there is an increasing recognition of the difficulties of undertaking multi-disciplinary collaborative projects involving systems development, particularly where such projects are multi-institutional involving academic, public and private sectors (Mitev & Venters, 2007). As science has become increasingly collaborative, new forms of organisation have emerged to manage scientific collaborations (Chompalov *et al*., 2002) of which Fosters' "Virtual Organisations using Grids" is one example (Foster et al., 2001). Such collaborative organisational forms blur the boundaries between researchers, sectors and disciplines (Chompalov *et al*., 2002) and, we here argue, impact upon the development practices involved in construction of the infrastructure upon which they rely. In particular collaborative, multi-organisational relationships are negotiated in "an ongoing communicative process", emerge from informal, ongoing relationships (Hardy *et al*., 2003) and challenge the traditional emphasis on formal agreements with identified goals, rational partner selection, and performance monitoring (Powell *et al*., 1996) aligned with traditional approaches to systems development practice (Avison & Fitzgerald, 2003a; Avison & Fitzgerald, 2003b). Through an analysis of the social construction of HealthscanGrid as a multi-disciplinary, multi-institutional project to develop Grid infrastructure, we aim to contribute to this ongoing discourse by highlighting how the collaborations' participants interpret their project and the technology differently during the development of the infrastructure, and so highlight how such interpretation influences the form of the resulting Grid and its associated "Virtual Organisations". In order to undertake such an analysis we employ a theoretical framework based on the social construction of technology.

3 THEORETICAL FRAMEWORK

In contrast to the deterministic views inherent in much of the literature on Grids we employ SCOT (social construction of technology) as an approach to help us look at how technology is constructed in society and through its use (Howcroft *et al*., 2004). While we acknowledge that there are alternative approaches to explain such a context (e.g. Actor Network Theory), we consider Grids as embedded in social systems and that their development is determined by social factors and by the meanings attributed to it by different groups (Kline & Pinch, 1996). We explore HealthscanGrid's development through SCOT as a means of understanding how the interpretations and interactions among different groups influence and eventually shape their final attitude towards the prototype (Orlikowski, 1992; Mitev, 2005).

Relevant social groups are a key starting point in SCOT. All members of each relevant social group within a collaboration or a community share the same set of meanings, interpretations and understandings for a specific artefact. Interaction between and within relevant social groups is argued to be critical for the development and existence of a technological artefact (Bijker, 1995). Hence, it is very important to take the artefacts as they are viewed by relevant social groups, in order to understand technological design, development, implementation and use (Howcroft *et al*., 2004). The set of meanings, interpretations, assumptions, expectations and knowledge members use to understand technology is called technological frames. In undertaking the analysis we explore the relevant social groups of people within the collaboration drawing upon Orlikowski and Gash's (1994) views. Technological frames are important in understanding technologies and change in organizations, as well as the implementation and use of information infrastructures. It is also useful to understand peoples' interpretations in order to understand their final attitude towards technology. Inconsistencies (incongruence) in the technological frames between the relevant social groups within a collaboration can create problems in developing, implementing and using technology, as well as a breakdown in communication, lack of participation by its users, etc (Orlikowski & Gash, 1994). The aspiration for a technology such as HealthscanGrid is that such problems of interpretation and conflicting images of the technology may cease as consensus (or domination by one group) occurs resulting in so called closure (Klein & Kleinman, 2002) leading to the stabilization of the artifact in its final form (Pinch, 1995; Kline & Pinch, 1999). It should be noted however that such stabilization is not static or final as further changes may occur.

In undertaking the research evidence was collected by reviewing HealthscanGrid documentation and undertaking six semi-structured interviews with key people; each interview lasting on average 1-2 hours. The people interviewed were representatives of the five institutions involved in the HealthscanGrid project; they were a project leader from PAL, a research dissemination coordinator from a university in the UK (UniversityWestUK), a chief scientist and a promoter of standardised technology from MedicalXYZ (not its real name), as well as two research associates from a hospital in the UK (HospitalUK).

4 CASE STUDY: THE HEALTHSCANGRID PROJECT

The medical community has been exploring collaborative approaches for managing, storing and analyzing image data and for exchanging knowledge. The Grid was seen to be a promising technology as it enables new collaborative approaches for image analysis without the necessity for clinicians to co-locate (McClatchey *et al*., 2003). The HealthscanGrid project was one of the first attempts to exploit Grid infrastructure within healthcare and aimed to investigate the feasibility of developing a European database of mammogram images, using a data grid to support collaboration among clinicians across the EU in medical diagnosis (Amendolia *et al*., 2004): "*The project wanted to allow doctors to exchange information and data in a transparent way, across borders, allowing them to perform many tasks, like epidemiological studies*". HealthscanGrid infrastructure was required to make available the large amounts of data as 'digital libraries' (Baker *et al*., 2002; Rajasekar *et al*., 2002) to healthcare institutions around Europe, as well as allowing its efficient management and analysis (Hauer *et al*., 2003). The project, launched in late 2002 and funded by the European Union, ran for three years ending successfully with the delivery of a prototype system to a Spanish private company who are currently trying to deploy it into a large-scale product of commercial value.

The project was a collaboration of many institutions from which five were heavily involved (all names have been changed) : HospitalUK (UK), HospitalItalia (Italy), UniversityWestUK (UK), MedicalXYZ – a small spin-off SME company (UK) and PAL the world's largest particle-physics accelerator laboratory (Switzerland). The Virtual Organization of HealthscanGrid's users (MGVO) consisted of three mammography centres: the HospitalUK (UK), HospitalItalia (Italy) and a UK university. The MGVO central node at PAL was coordinating the access (Rogulin *et al.*, 2005) with PAL's role being to provide the Grid expertise, and also leading the project as project-coordinator. MedicalXYZ's role was to adapt their already existing mammogram software to meet the HealthscanGrid's requirements. The UniversityWestUK was responsible for gathering comprehensive requirements from users and for the development of the database. Finally, the hospitals involved represented the end-users of the project, providing the information and medical data to go into the HealthscanGrid, as well as the requirements and feedback to the developers. The deliverable of the project was a software prototype, capable of allowing complex epidemiological studies, statistical and computer aided detection analyses and the deployment of versions of the image standardization software (ibid). The prototype was considered to be a success by its collaborators, despite some small failures, its lack of user-friendliness, and the fact that some features had not been developed.

That there were five different institutions, involving people from different disciplines and with conflicting priorities and expectations, made the collaboration more difficult; something that held back the project: *"There was the commercial company, talking to research people and each group was not appreciating the other ones work. They all had different goals and priorities. Commercial people were concerned with profit and researchers wanted their job being done."* Although they were involved for different reasons in the project, only one thing linked them together: *"Each institution applies for funding… People are meeting together for a common purpose: the funding…It is just business…"* Even though the project can be seen as a success in the end, most of the collaborators felt disappointed in terms of poor teamwork and leadership as well as the fact that they had given more input and effort in comparison with what they had received in return. As one respondent said in an interview: *"The HealthscanGrid could have great results, it could have been better if people behaved and talked to each other. Two of the teams involved could not work together, could not collaborate."*

During the development and implementation of HealthscanGrid a number of problems emerged. The group from PAL that had developed the grid technology had not taken into account a lot of the requirements of medical computing, for example the necessity for security and confidentiality. There were also problems with communication as HospitalItalia hospital in Italy couldn't "talk" to its own software; therefore, doctors from HospitalItalia had to travel to Cambridge in order to see their images, as well as Cambridge's images: *"The technical 'hiccups' were holding back the project. MedicalXYZ's software wouldn't talk to Switzerland's software and the only thing they did was just blaming each other."* Furthermore, the hospitals hesitated to share medical data feeling that the data belonged to the hospitals and that they should not risk losing the potential for their doctors to use the data for publishing research papers.

One of the interviewees argued that partners were not visualizing the benefits received from the project and that they had, as a result, not put much effort in making agreements to ensure success. They also did not agree on a set of procedures for software development beforehand, which made the development even more frustrating: *"We knew about updates of the libraries only by finding out that one day, the workstation stopped working. After spending 2 weeks on it, we realized that the libraries had changed and nobody told us. That was 2 weeks totally wasted."*

The gathering of user requirements also proved difficult as different partners did not appreciate the demands on other partners. Developers were faced with trying to make clinicians understand that once features are defined they need to be developed, tested and reviewed before the next round of features came up. There were numerous situations where the set of features were gathered and agreed but the list kept on increasing while development was happening without proper control. That ended up with clinicians frustrated, since they felt that MedicalXYZ, was not doing its job, and was not delivering the software to them. MedicalXYZ however argued that clinicians did not realize that the list of features they were asking for necessitated excessive man power in comparison to what was budgeted for in the project.

During the course of the project MedicalXYZ was acquired, firstly by a specialist company and then by a larger multinational creating many problems and tensions during the development, since the priorities of the company necessarily shifted dramatically away from the HealthscanGrid project and MedicalXYZ stopped providing any input to the project: *"…With a little more effort from MedicalXYZ in the last phase of the project, we could have had a better prototype, with some functionalities be better developed… If there is something it doesn't work as it should, it's because at a certain time MedicalXYZ deployed a product which was not the full thing they could build…"*

5 ANALYSIS

In undertaking the analysis three relevant social groups were identified to be the most central among the project participants. We describe each in turn before analysing the case through which these groups socially constructed HealthscanGrid, influenced by their differing interpretations. In particular we consider how these relevant social groups' framings of the technology and the project shaped HealthscanGrids' development.

5.1 Relevant Social Groups

Academic-Developers' group

This group comprised two institutions; the particle physics group from PAL and the team of academics and PhD students from UniversityWestUK. The team from UniversityWestUK was based at PAL during the deployment of the project which made them share similar expectations, understandings and assumptions concerning the HealthscanGrid with the particle physicists. Particle physicists are always a few years ahead in terms of computing. They are very pragmatic in the way they develop technology (Hlistova, 2004) and have a reputation for getting things done. As one interviewee stated *"PAL succeeds; there could be delays and small problems in developing technologies, but they always manage to solve them"*. They pursued the opportunity to be involved in the project because they wanted to provide the knowledge they had acquired from fundamental physics to something that could benefit society at large and to respond to the criticism that physicists kept all the knowledge to themselves and only cared about solving their own problems. The academics had backgrounds in computer science and information systems with an interest focused on research. For them the project was an opportunity to engage in the development of a Grid; get involved in a European project, and use the knowledge acquired from previous projects based at PAL.

Commercial group

The Commercial group comprised of staff at MedicalXYZ, a small start-up company interested in business, growing as a company and making money. They were focused on two projects: image fusion and mammographic image processing. At the beginning of HealthscanGrid, the computing competency and technical skills of the Commercial group was low, so the project was an opportunity for them to: (1) get access to the Grid technology and gain the technical expertise and core competencies for any advanced product using the Grid and (2) expand their panel of collaboration partners, so that data and clinical expertise would be available: *"The main expectation for us was to demonstrate that we can access remote data through the Grid and perform state-of-the-art visualization for it. Commercially, it was important for us to be visible as technical leaders"*. While the project was still running, the company was taken over by a larger company and consequently their focus changed and mammography stopped being central to their activities. From then on the resources they provided were restricted.

Health Care Users' group

Clinicians were the end-users of the project; there was little computing competency or technical skills among them and their interests had nothing to do with commercial work. Their goals as a community were three-fold: Firstly, to improve the techniques for breast cancer diagnosis, secondly, to push forward the frontiers for using software in healthcare, and thirdly to promote teamwork among hospitals for clinical research.

5.2 Analysis of the Social Construction of HealthscanGrid

Having identified relevant social groups we now consider how the interaction between them shaped the project and the resulting HealthscanGrid technology. In doing so we consider the technology's development, its capabilities, its use, and the expectations of the groups concerning HealthscanGrid's future. It is worth noting however that in addition to the groups above, most participants in HealthscanGrid agreed that a strong influence on the project was presented by the EU as the funding body. "*There was clearly a leader and that was the European community...if we didn't deliver, we wouldn't get the money and the project would stop"*. This reflects the strong influence funding bodies have on multi-disciplinary research (Newell *et al*., 2001) and in particular the need for 'solutions' to reflect the pre-specified 'deliverables' set out in project funding proposals (Newell *et al*., 2001).

The relevant social groups became involved in initiating the project for different reasons. The expectations of the high impact the Grid could have in medicine was the primary reason the project was initiated from the particle physicists within the Academic-Developers' group who felt that the Grid at PAL, and the advanced techniques they had developed, could be adapted in the medical field and lead to a very important output: *"…This approach is clearly the future of communication in medicine"*. The team of academics within this group expected that HealthscanGrid could not only help improve breast cancer diagnosis but, if successful, be adapted and used for other applications in medicine. Contrary to this, the Commercial groups' expectations concerned the impact HealthscanGrid could have on their company's strategy, structure, status and way of doing business. The company was small, had little technical expertise and had no experience of the Grid. From what they had heard, they knew that HealthscanGrid could provide them with the technical expertise they badly needed and commercially it would make them visible as technical leaders. Finally, clinicians wanted a system that could provide a solution to the problems surrounding breast cancer today. No technical expertise existed within their team, so they were introduced to the Grid and what it could do in medicine by the Academic-Developers' group. Having understood its importance and the impact it could potentially have in saving lives, they agreed to initiate the project and collaborate with the other institutions. Such divergent interpretations of the project proposal, and subsequently differing motivations for involvement, suggest the kind of 'mechanistic pooling' evident in previous reports on multi-disciplinarity (Newell & Galliers, 2000) whereby "each member of the pool [is] taking a different 'slice' of the project and the work then proceeds with the minimum of communication between members" (Knights & Willmott, 1997). Indeed in HealthscanGrid such pooling went beyond the theoretical differences between academic disciplines (highlighted in Newell & Galliers (2000)), to include issues of profit and motivation alongside research contribution.

The functionalities and capabilities HealthscanGrid would provide, how it would be used on a daily basis and the consequences of its usage were not clear to the groups, and the groups had different expectations concerning its future. The Academic-Developers' group knew from previous experience that HealthscanGrid could provide capabilities that at the time did not exist in healthcare in particular facilitating communication, sharing and storing of data and information across hospitals linked to the system in a transparent way and without a loss in their quality. They also expected that the HealthscanGrid would be used for epidemiological studies, as a second opinion doctor, as well as for the comparison of similar breast cancer cases. However, their interpretations concerning HealthscanGrid led them to emphasize the advanced technical capabilities and leave other aspects aside: *"The system was conceived with specifications which were aiming at making it user-friendly and automated. However, not all of these functionalities were implemented, but we had said from the beginning that some aspects could be left behind"*. Those among this group with an academic career seemed to be more focused on exploring advanced technology than on the practicalities. This is unsurprising given their expectation that a successful prototype would provide them with a large number of PhDs and publications upon which their personal success is judged. To them it was just a prototype and hence basic capabilities, such as being user-friendly and automated, were not as important as exploring advanced capabilities of research interest. Also important was the potential for it to become a commercial product as some point in the future rather than as an outcome of the project: as a member of this group stated *"We hope to see the son of HealthscanGrid based on a commercial grid used by doctors in an efficient way. We know that it is quite difficult to be adopted, especially at the beginning. But just look at medicine today compared with 20 years ago. It can happen"*. On this basis the group made assumptions regarding the use of the technology by doctors, and assumed it did not require a formal implementation and training plan, though they did highlight the need for security, patient consent and confidentiality to be considered, but again in the long term: *"If you want to use this project in real life, you need to ensure that the data you are using has been consented…"*.

The Commercial group in contrast learned about the Grid while searching for a technology to support the two projects they were working on at the time. They felt that the Grid could bring a revolution in communication and sharing of data and give them the opportunity to develop better algorithms for their projects. Their expectations and assumptions concerning how the HealthscanGrid would be used on a daily basis were not so clear. They knew that the project could help them commercially and, in the opinion of those interviewed, that was the only thing they cared about. Regarding the consequences of the actual usage of the HealthscanGrid, they argued that one possible problem could be the fact that hospitals might not wish to share their data: *"All institutions work for themselves. You need to give them value in return for what they are giving you"*. From the Commercial groups' perspective their expectations concerning the final output were more aligned to acquiring technical expertise throughout the development of the system, rather than expecting benefit from the actual prototype itself. What they really needed was to be visible as technical leaders in the market field, a goal they achieved evidenced by their acquisition by a larger company, and later by a well known international engineering and electronics company.

Health Care Users felt they understood that technology would support collaboration between doctors from hospitals connected to the HealthscanGrid and would have the capability of gathering and storing large amounts of data in one place. They felt it would facilitate teaching and real-time usage so that clinicians would be able to collaborate during surgery. Since they had little experience with technologies, they expected that a formal implementation and training plan would be provided. Concerning the technology's daily usage they expected that the system could be used for epidemiology studies, as a second opinion doctor, as a teaching aid, as well as to be used in some way within surgery. Their main concern regarding its use was in terms of security and confidentiality. Clinicians' expectations about the final output were of a system that could improve clinical diagnosis, project cancer risk accurately, be used in a real-time basis during surgery and as a teaching tool. As one clinician stated: *"Imagine a room full of young radiologists and clinicians teaching them... It will be fantastic"*. Furthermore, they expected the system to be user-friendly and automated. When the prototype was delivered to the doctors and put into use they found it extremely hard to cope with, since it was not user-friendly and did not meet their requirements.

At the end of the project the necessity to comply with the EU funding requirements, rather than common consensus, ensured that the relevant social groups completed their stated objectives on time. This ensured that a form of closure and stabilization was achieved and documented in the final project submission. The groups knew that if they did not deliver what they had promised and what the EU was paying for, they would not get the money and they would have to explain why this happened. As one interviewee stated: *"…What needs to be done, has to be done to deliver; if it wasn't being done, then we would all work as a team to get it done…If one of us failed, all five of us failed. We had to make sure that all five of us would succeed, otherwise we would all be giving back our money."* Therefore, all groups reached a form of closure and stabilization, because in a way they had to. They put aside their expectations and understandings concerning the HealthscanGrid, and they all worked together in order to manage to deliver.

6 DISCUSSION

The HealthscanGrid project was considered to be one of the first attempts at applying Grid technology in healthcare. Consequently, the fact that the prototype delivered and has the potential of becoming a useful and sellable product will play a significant role in the future of using software for collaborative clinical diagnosis and treatment in healthcare. The problems relevant social groups faced during the development and use of the prototype were plenty, and yet their alignment to the funding requirements ensured that they managed to reach a form of closure and stabilization under duress. The prototype was socially constructed and embodied the relevant social groups' expectations, constraints, conflicts, interests and knowledge. Hence, even if a form of closure and stabilization is forced, the possibilities of the conflicting frames to reappear are high, a fact that might lead to difficulties concerning the adoption of the technology, and its incorporation in users' work practices (Pinch & Bijker, 1987).

We now consider how our case study of the social construction of the HealthscanGrid prototype might inform those involved in multi-disciplinary projects to construct Grids, and those funding such endeavours. In particular we concentrate on multi-disciplinary projects' interpretations, rather than considering such projects as the 'mechanistic pooling' (Newell et al., 2001) of knowledge and skill necessary for the construction of a Grid infrastructure. We see this as important because, like many multi-disciplinary research projects, HealthscanGrid appears to have been leaderless (Chompalov *et al*., 2002) in nature and hence the relevant social groups involved in its development mutually shaped the outcome. As one interviewee argued: *"HealthscanGrid did not get quite there, but the potential is certainly there. What is needed is strong leadership and well defined collaboration processes. European projects often lack these. Being from a non-academic side makes these gaps even more evident"*. Indeed when disagreement occurred the main leadership within the project was provided through the funding *"People just stopped talking to each other…when this happened, [the funding representative] was shouting at them. He said 'that's it, pack up the project and give me back the money. That's when they got scared and started being nice to each other. They had to, because they had promised the EU to deliver. So, they needed someone to shout at them"*. This suggests that, while hierarchical control is perhaps neither desirable or achievable within multi-disciplinary Grid development projects, future projects should be ready to confront conflicts among the relevant social groups by discussing their interpretations of the project, as well as making sure that the conflicting groups are led, not simply by the expectations of the funding council (as Mitev and Venters observed (2007)), but by consideration of the requirements of the Grid for its potential users and the timescales within which it will be used.

HealthscanGrid, and Grid technologies in general, enable and demand collaboration and multi-disciplinary research. Their size and complexity create the need for teams constituted from many different institutions in industry and university settings, and the focus of Grids is upon supporting collaboration. These cross institutional collaborations are deterministically encoded in the technical rules of the "Virtual Organisations" which enable and constrain the use of a particular Grid. Such "Virtual Organisations" reflect elements of the technological frames of the relevant social groups involved in the Grid's social construction. The way such relevant social groups negotiate the Grid will become embedded in the rules which define these Virtual Organisations and thus form part of the infrastructure of the Grid. A successful Grid therefore depends on the capacity of participating members to make an effort to work together, and share responsibility for achieving mutually determined and desired goals (Gray, 1989). As Mattessich, Murray-Close *et al*. (2001) argue some of the factors necessary for successful collaboration are mutual understanding and respect, informal and personal relationships, open and frequent communication, shared vision, concrete and achievable goals, flexibility and adaptability, and a favourable political and social climate, from which some were lacking from the HealthscanGrid collaboration. In the case of the HealthscanGrid, the relevant social groups were not visualizing the benefits received from the project and as a result appear to have put less effort into ensuring success. As one interviewee argued, two groups within the project could not collaborate and be a part of a team, which led to the interaction between them being minimal and to each group centrally controlling its own bit. This, unsurprisingly led the different relevant social group's vision of the final prototype to differ greatly; as a prototype of academic value; a demonstrator of technical skill; and a final product of immediate value to clinicians. In turn this influenced the MGVO Virtual Organisation as security polices were under-developed, updates of libraries were not controlled, and training was not provided.

It is important to diminish the gap between the developer's and users' understandings and expectations. Technology is considered as a text which is read in different ways by various actors (Brey, 1997). As Orlikowski and Gash (1994) argue, "People's interpretation of a technology is critical to understanding their interaction with it. To interact with technology, people have to make sense of it; and in this sense making process they develop particular assumptions, expectations and knowledge of technology, which then serve to shape subsequent actions towards it”. Therefore, the developers’ task should be to understand how particular readings of the technology by different groups come to prevail if relevant and useful Grid infrastructure is to be developed and implemented.

7 CONCLUSION

This paper examined the case of the HealthscanGrid project, a project which investigated the feasibility of developing a European database of mammograms, using Grid technology to support collaboration between clinicians across the EU. Specifically, the focus of concern was to explore the development of HealthscanGrid and its impact on final product, using concepts from SCOT as a lens.

The HealthscanGrid case study highlights that while collaborative multi-disciplinary EU funded projects may be advantageous in order to bridge the ‘relevance gap’ (Starkey & Madan, 2001) by ensuring that Grids reflect the needs of users within various sectors rather than just computer science; we should not forget that such disciplines have different reasons for participating in such projects. While producing relevant Grids is important, we highlight here the necessity for those involved in leading Grid development (including funding bodies) to appreciate the interpretation of the project made by its participants. While we might aspire to create seamless, transparent distributed Grid resources (Chetty & Buyya, 2002), this study outlines how socio-technical problems (such as those associated with training, security, usability and networking within the resulting prototype) may be linked through the requirements gathering to the varying interpretations of the project by the relevant social groups involved.

If Grid’s are indeed to support global collaborative working practice then we should consider how conflicting interpretations by the relevant social groups towards the technology and the project become embedded within Grids’ “Virtual Organisations” rather than considering Grids as a transparent infrastructure. The “Virtual Organisations” of Grids are more than just a technical mapping of the anticipated Grid users collaboration; we suggest here that they are a socially constructed formula which represents the negotiation of the relevant social group’s collaboration in the Grid’s construction – and are thus central to the stabilization of the technology in use, and hence to the project’s success. If projects simply ‘mechanistically pool’ the expertise of the participant disciplines then such stability of Grids may prove difficult to achieve.

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8 REFERENCES

Amendolia, S. R., Estrella, F., Hauer, T., Manset, D., Mcclatchey, R., Odeh, M., Reading, T., Rogulin, D., Schottlander, D. and Solomonides, T. (2004) Grid databases for shared image analysis in the [HealthscanGrid] project. In *8th International Database Engineering & Applications Symposium*, Portugal.

Avison, D. and Fitzgerald, G. (2003a) *Information systems development: Methodologies, techniques and tools.* McGraw-Hill, London.

Avison, D. and Fitzgerald, G. (2003b) Where now for development methodologies. *Communications of the ACM* 46 (1), 79-82.

Baker, M., Buyya, R. and Laforenza, D. (2002) Grids and grid technologies for wide-area distributed computing. In: *Software practice and experience*, John Wiley & Sons.

Berman, F., Geoffrey, F. and Hey, T. (2003) The grid: Past, present, future. In *In: Grid computing-making the global infrastructure a reality* (Berman, F. and Geoffrey, F. and Hey, T., Eds), John Wiley & Sons.

Bijker, W. (1995) *Of Bicycles, Bakerlite and Bulbs; Toward a theory of socio-technical change.* MIT Press, Cambridge, MA.

Brey, P. (1997) Philosophy of technology meets social constructivism. *Society for Philosophy and Technology* 2 (3-4),

Broadbent, M. and Weill, P. (1999) The implication of information technology infrastructure for business-process-redesign. *MIS Quarterly* 23 (2), 159-182.

Carr, N. (2005) The end of corporate computing. *MIT Sloan Management Review* 46 (3), 67-73.

Chetty, M. and Buyya, R. (2002) Weaving computational grids: How analogous are they with electrical grids? *Computing in Science & Engineering* 4 (4), 61-71.

Chompalov, I., Genuth, J. and Shrum, W. (2002) The organization of scientific collaborations. *Research Policy* 31, 749-767.

Cordella, A. (2006) Information infrastructure in action. London School of Economics and Political Sciences, Department of Information Systems.

Foster, I., Kesselman, C. and Tuecke, S. (2001) The anatomy of the Grid. *International Journal of Supercomputer Applications* 15 (3), 200-222.

Gray, B. (1989) *Collaboration: Finding common group for multi-party problems.* Jossey-Bass Publishers, San Francisco.

Hanseth, O. (1996) Information technology as infrastructure. *School of Economics and Commercial Law*, Goteborg University, Goteborg.

Hanseth, O. and Monteiro, E. (1998) Understanding information infrastructure. *http://heim.ifi.uio.no/~oleha/Publications/bok.html*.

Hardy, C., Phillips, N. and Lawrence, T. B. (2003) Resources, knowledge and influence: The organizational effects of interorganizational collaboration. *Journal of Management Studies* 40 (2), 321-347.

Hauer, T., Amendolia, S. R., Warsi, I., Mcclatchey, R., Odeh, M., Solomonides, T., Warren, R., Del Frate, C., Bazzocchi, M. and Schottlander, D. (2003) Requirements for large-scale distributed medical image analysis. In *Proceedings of the 1st EU HealthGrid Workshop*, Lyon, France.

Hlistova, J. (2004) How is the particle physics community shaping the grid in the UK: An ANT study of the emergence and adoption of an information infrastructure. *Department of Information Systems* London School of Economics and Political Sciences, London, UK.

Howcroft, D., Mitev, N. and Wilson, M. (2004) What we may learn from the social shaping of technology approach. In: *Social theory and philosophy for information systems* (Mingers, J. and Willcocks, Eds), John Wiley & Sons, Chichester.

Inzelt, A. (2004) The evolution of university-industry-government relationships during transition. *Research Policy* 33 (6-7), 975-995.

Klein, H. and Kleinman, D. (2002) The social construction of technology: Structural considerations. *Science, Technology and Human Values* 27 (1), 28-52.

Kline, R. and Pinch, T. (1996) Users as agents of technological change: The social construction of the automobile in the rural united states. *Technology and Culture* 37 (4), 763-795.

Kline, R. and Pinch, T. (1999) The social construction of technology. In: *The social shaping of technology* (Mackenzie, D. and Wajcman, J., Eds), Open University Press, Buckingham

Knights, D. and Willmott, H. (1997) The hype and hope of interdisciplinary management studies. *British Journal of Management* 8 (1), 9-14.

Mattessich, P. and Murray-Close (2001) *Collaboration: What makes it work.* Amherst H. Wilder Foundation,, St Paul, Minnesota.

Mcclatchey, R., Manset, D., Hauer, T., Estrella, F., Saiz, P. and Rogulin, D. (2003) The [healthscanGrid] project grids architecture. In *Proceedings of the 10th International Conference on Computing for High Energy Physics (CHEP'03)*, San Diego, USA.

Mitev, N. (2005) Are social constructivist approaches critical? The case of is failure. In: *Handbook of critical information systems research* (Howcroft, D. and Trauth, E., Eds), Edward Elgar.

Mitev, N. and Venters, W. (2007) Self-reflexive evaluation of an academic-industry management research collaboration: Instrumentalisation in developing knowledge management technology. *Journal of Management Studies* (Under second review).

Newell, S. and Galliers, R. (2000) More than a footnote: The perils of multidisciplinary research collaboration. In *Americas Conference on Information Systems* (Chung, H. M., Ed), pp 1738-1742, Long Beach, California.

Newell, S., Swan, J. and Kautz, K. (2001) The role of funding bodies in the creation and diffusion of management fads and fashions. *Organisation* 8 (1), 97-120.

Orlikowski, W. J. (1992) The duality of technology: Rethinking the concept of technology in organizations. *Organization Science* 3 (3), 398-427.

Orlikowski, W. J. and Gash, D. C. (1994) Technological frames: Making sense of information technology in organizations. *ACM Transactions on Information Systems* 12 (2), 174-207.

Orzech, D. (2003) Politics, not technology, is biggest barrier to grid computing. GridComputingPlanet.com.

Pinch, T. (1995) The social construction of technology: A review. In: *Technological change: Methods and themes in history of technology* (Fox, R., Ed), Martin Dunitz.

Pinch, T. and Bijker, W. (1987) The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other. In: *The social construction of technological systems: New directions in the sociology and history of technology* (Bijker, W. and Hughes, T. and Pinch, T., Eds), MIT Press, Cambridge, UK.

Porac, J., Wade, J., Fischer, H., Brown, J., Kanfer, A. and Bowker, G. (2004) Human capital heterogeneity, collaborative relationships, and publication patterns in a multidisciplinary scientific alliance: A comparative case study of two scientific teams. *Research Policy* 33, 661-678.

Powell, W., Koput, K. and Smith-Doerr, L. (1996) Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly* 41 (1),

Rajasekar, A., Wan, M. and R, M. (2002) MySRB & SRB - components of a data grid. In *Proceedings of the 11th International Symposium on High Performance Distributed Computing (HPDC-11)*.

Rogulin, D., Estrella, F. and Mcclatchey, R. (2005) A service-based grid environment for managing distributed medical images. *Submitted to the 6th International Conference on Web-Age Information Management (WAIM 2005)*.

Scott, S. and Venters, W. (2007) The practice of e-science and e-social science: Method, theory, and matter. In: *Virtuality and virtualization: IFIP 8.2* (Orlikowski, W. and Wynn, E. and Crowston, K. and Sieber, S., Eds), Kluwer Academic Publishers, Portland OR.

Smarr, L. (2004) Grids in context. In: *The Grid2: Blueprint for a new computer infrastructure* (Foster, I. and Kesselman, C., Eds), Elsevier Inc.

Starkey, K. and Madan, P. (2001) Bridging the relevance gap: Aligning stakeholders in the future of management research. *British Journal of Management* 12 (Supplement 1), S3-S24.

Venters, W. and Cornford, T. (2006) Introducing PEGASUS: An ethnographic research project studying the use of grid technologies by the UK particle physics community. In *Second International Conference on e-Social Science*, Manchester, UK.

Wladawsky-Berger, I. (2004) The industrial imperative. In: *The grid2: Blueprint for a new computing infrastructure* (Foster, I. and Kesselman, C., Eds), Elsevier Inc.