FINAL REPORT

The Collective Consciousness of Information Technology Research: The Significance and Value of Research Projects

A. The Views of IT Researchers

Christine Bruce

Binh Pham

Ian Stoodley

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Prelude

The collective consciousness of effective groups of researchers is characterised by shared understandings of their research object or territory. In the relatively new field of information technology research, rapid expansion and fragmentation of the territory has led to different perceptions about what constitutes significant and valuable research. These different views deter the investigation of contemporary problems and issues requiring inter and intra-disciplinary collaboration amongst research groups, and limit the potential for technology transfer to industry. This project explores a facet of the collective consciousness of disparate groups of researchers and lays a foundation for constructing shared research objects.

Abstract

This research seeks to reveal the different perceptual worlds in a research community, with the long-term intent of fostering increased understanding and hence collaboration. In the relatively new field of information technology (IT) research, available evidence suggests that a shared understanding of the research object or territory does not yet exist. This has led to the development of different perceptions amongst IT researchers of what constitutes significant and valuable research.

A phenomenological approach is used to elicit data from a diverse range of IT researchers in semi-structured interviews. This data is presented to show (1) the variation in meaning associated with the idea of significance and value and (2) the awareness structures through which participants experience significance and value. An Outcome Space represents the interrelation between those different ways of seeing, revealing a widening awareness.

Five categories of ways of seeing the significance and value of research projects were found: The Personal Goals Conception, The Research Currency Conception, The Design of the Research Project Conception, The Outcomes for the Technology End User Conception and The Solving Real-World Problems Conception. These are situated within three wider perceptual boundaries: The Individual, The Research Community and Humankind. The categories are described in detail, demonstrated with participants' quotes and illustrated with diagrams.

A tentative comparison is made between this project and a similar investigation of IT professionals' ways of seeing the significance and value of IT research projects. Finally, some recommendations for further research are made.

Contents

Note: References following quotes give the interview number, transcript page number and approximate position on the page, from a to d e.g. '10.6b' refers to interview 10, page 6, section b.

1 Introduction

> *... there are various explications of the way science moves forward ... and by science, I mean science in a broad sense of people finding out things, testing them ... and being able to apply them ... but ... the influential people tend to think that ... you've got to have a mental framework in which they're applied ... which is why you've got to have the conceptual understanding that people working in the same area can share, and then in order to apply them you've got to have principles that operate within that conceptual framework ... (10.6b)*

This research seeks to reveal the different perceptual worlds in a research community, with the long-term intent of fostering increased understanding and collaboration.

The collective consciousness of a research group is characterized by their shared understandings of their research object or territory (Bowden and Marton, 1998, p.196). In the relatively new field of information technology (IT) research, available evidence suggests that such a shared understanding does not yet exist. Since the establishment of IT research, Information Systems (IS) and Computer Science (CS) researchers, for example, have come to focus on very different territories. They investigate areas as diverse as data mining, cryptography, database architecture, multi-media, e-commerce, information management and information science. The narrow focus of CS researchers on technical issues, formal methods and abstract thinking has been broadened to encompass a wide range of issues related to the use of computer technologies (e.g. management of information systems, social impacts) that are usually the domain of IS researchers. New opportunities for multidisciplinary research are also emerging, addressing issues which may be seen to belong to, for example, life-science, education, management and art. All of this has led to the development of different perceptions amongst IT researchers of what constitutes significant and valuable research.

IT researchers' understandings of the research domain continue to transform and to fragment, in order to account for users' diverse needs. Although the general aim is still to seek better methods, systems and performance, urgent problems include how to transform work practices and recognize opportunities for innovation in other sectors such as business, science, engineering and government. New technologies have stimulated a surge of new approaches for development in industries such as electronic publishing and remote sensing for mining and agriculture. New industries, markets and employment patterns have therefore emerged. Political and economic pressures are forcing university researchers to adopt a more outward-looking attitude, which encourages closer interactions and collaborations with industry and community. Investigating the problems and issues of these new frontiers ideally requires collaboration between different groups of IT researchers. While new research areas have been created to cope with such demands, progress is generally deterred by disagreement, conflict, and a general lack of cooperation between the different research groups. One of the primary manifestations of this conflict is different views of the significance and value of particular kinds of investigations.

Cooperation and collaboration are further confounded by the adoption of research approaches from across a range of theoretical foundations. Thus, although IT researchers are commonly focused on the world of information technology, the research interests of the various subgroups rarely intersect. Their differences are not only about what research object it is appropriate to investigate, but also about how such investigations should be conducted. Consequently, joint projects between the different groups and interdisciplinary research are comparatively rare. While the question of what is considered to be valuable and significant IT research remains contentious and unexplored this situation is unlikely to change. Exploring this question will help us to discover possible shared elements in the many research interests, thus strengthening our understanding of one facet of the IT research object and its associated problems.

So far, most investigations which include some comparative analysis of the information technology domain have been in three main categories: social impacts (e.g. Williams and Edge, 1996; Sahay, 1997), education (AVCC, 1996; Bruce, 1996; Pham, 1997) and economic development (Roche, 1996). Very little effort has been focused on the comparative analysis of different IT research areas, with the exception of some work by Simon (1999) on how IT research is being conducted in the United States.

This project begins to illuminate what are presently hidden agendas and largely unarticulated views about what constitutes valuable and significant IT research. Such an illumination is not intended to produce agreement. Rather, it will develop a process of critical reflection and produce a preliminary framework within which researchers can understand their differences and seek avenues for research convergence and cooperation.

2 Aim of project

This project aims to investigate variation in what researchers consider to be significant and valuable contributions to the field of information technology research. Immediately useful outcomes will be available to the IT profession in the form of a framework that:

1. Will illuminate one dimension of the collective consciousness of IT research;
2. Will allow researchers and industry partners to critique their own reasons for engaging in particular forms of IT research;
3. May be used to facilitate technology transfer of research results to industry;
4. May be used to facilitate inter-disciplinary research as well as collaboration between IT groups, by making explicit their varying experience of one aspect of the research agenda; and
5. Will lay a foundation for further investigation of IT researchers' collective consciousness.

The outcomes represent different ways of seeing the significance and value of IT research from a broad perspective, without directly associating them with specific disciplines or subdisciplines. The intention is not to classify specific researchers or groups of researchers, but rather to identify different ways of thinking that may change with the context in which they work. This will allow researchers from the various groups to interact with the framework freely.

3 Method

3.1 Approach

Since the early 1970s, phenomenographic methods (Marton and Booth, 1997) have been used extensively, and successfully, to investigate variation in ways of perceiving or experiencing phenomena. These techniques are now beginning to be used to investigate the collective consciousness of research communities (Bowden and Marton, 1998). Phenomenography is "a description of appearances" (Phenomenography – Terminology, 1996), it is "the empirical study of the differing ways in which people experience, perceive, apprehend, understand, conceptualise various phenomena in and aspects of the world around us" (Marton, 1994).

3.2 Data gathering and preparation for analysis

Semi-structured individual interviews of approximately 30 minutes each were conducted with volunteer IT researchers. These interviews served as mechanisms for encouraging participants to articulate their views. 'Trigger' questions were designed to elicit differences in the attribution of value and significance to IT research. They were designed to be broad enough to obtain meaningful responses in relation to the aim without forcing a particular structure, or way of responding, upon participants. Each question served as an 'opening', from which the interviewer developed a trail of further questions in order to achieve a shared understanding of the participants' perspectives.

As a result of two pilot interviews the interview questions were modified slightly. Nevertheless, the data from the pilot interviews was considered to be of a high quality and was included in the analysis. Furthermore, consultation with Ference Marton resulted in minor adjustments to the questions after Interview 4.

The final version of the trigger questions put to the researchers follows:

1. Can you tell me briefly about your current research and explain its significance and value?
2. What kinds of research projects do you see as being considered significant, valuable within your research group? What makes them significant and valuable?

3. In your view, are the projects described in these abstracts significant? Explain.
   [A selection of abstracts were supplied, representing a range of types of IT research. Abstracts were selected to generate conflicting views. See Appendix.]
4. How do you in general know whether specific projects are significant and valuable?
5. In your experience, how useful or significant are the different branches of IT research, as you perceive them? Explain.

After completion of the interview, tapes were transcribed verbatim and checked by the interviewer. Copies of the interviews were sent to the participants for information and comment.

In order to contain the scope of the study, this investigation was geographically confined to South East Queensland.

3.3 The analysis process

The analysis of the interview data was an iterative process involving a team of four researchers. In keeping with existing views of phenomenographic analysis, the process is considered to have commenced during the interview when the interviewer sought to understand the interviewees' ways of seeing the significance and value of IT research projects. After transcription of the interviews, two members of the research team focussed on analysing the data. This involved seeking (1) the variation in meaning associated with the idea of significance and value; this variation is referred to as the referential component of the categories of description and is described in the next section and (2) an understanding of the awareness structures through which participants experienced significance and value; these awareness structures form the structural component of the categories of description and are also further described in the next section.

3.4 Conceptual framework guiding analysis

A. Categories of description

In the analysis the participants' different ways of seeing what constitutes significant and valuable IT research are presented as categories of description. Each category of description is comprised of two parts:

1. a referential component, in which the meaning of the category is captured. This referential component is visible in the title of the categories and the brief descriptions accompanying them.
2. a structural component, in which the awareness structure associated with the referential component is made explicit. This structural component is represented in the diagrams and in the specification of the focus and perceptual boundaries associated with each category.

In the structural component of each category the awareness structure is delimited in terms of an external horizon, an internal horizon with stable and variable components, and dimensions of the internal horizon's variable components:

a) The *External Horizon* represents the outer limits, or perceptual boundary, of the participants' ways of seeing. The external horizon identifies that part of the world beyond which participants, who are looking at the world in a particular way, do not see. For example, in Category 1 participants seeing significant and valuable projects as those which contribute to their personal goals do not look beyond their individual needs or interests. In this way of seeing, therefore, the individual (here the IT researcher) forms the external horizon of the category.

b) The *Internal Horizon* represents the focus of the participants' attention. The *stable aspect* in the internal horizon of each category remains constant across any possible subcategories and in this sense is the central component in identifying the particular way of seeing. The *variable aspects* in each way of seeing serve to distinguish between subcategories. For example, in Category 1 the focus characterising the way of seeing of all participants in this category is their personal goals. These personal goals may be further differentiated in terms of those which interest the participant and those which return some gain to them.

c) *Dimensions* associated with the variable aspects of the focus are proposed, however these are meant to be illustrative only and many others may be possible. They are included in the description of each subcategory. For example, within Subcategory 1b 'Professional gain' participants may assign significance and value to a project because it advances their career in some way or because it contributes to their own research.

Each category is accompanied by a diagram illustrating the awareness structure with which it is associated. Figure 1 shows how the external horizon (perceptual boundary) and internal horizon (focus), comprised of stable and variable components, are graphically depicted.

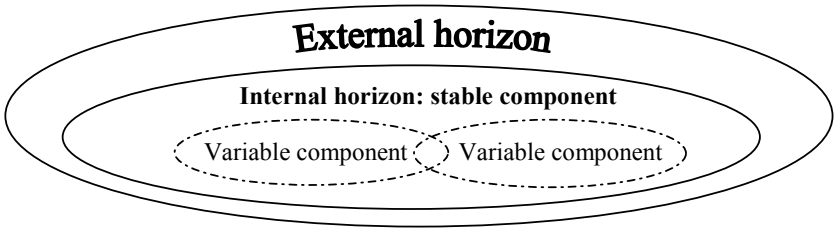

Figure 1 : Key to components of the awareness structure for each category

It should be noted that it was not possible to describe Category 2, Research Currency, in terms of elements of focus due to a lack of data. More research is required to further illuminate this category.

B. Outcome space

While the Categories of Description represent the varying 'ways of seeing' discovered amongst the participants, the Outcome Space represents the interrelation between those different ways of seeing. The outcome space is thus constructed to depict a holistic picture of the different ways of seeing in one segment of the IT research community.

Outcome spaces have, in different projects, been found to represent historical views of a phenomenon, or to represent a hierarchy of increasing complexity and sophistication. In this study the outcome space is constructed to reveal the widening awareness, the broadening of the perceptual boundary across the categories.

It should be noted that there is often in any one researcher's way of seeing an overlap between the different categories, resulting in a multi-dimensional view of significant and valuable research projects. It should further be noted that the same project may be assigned significance and value for different reasons, or indeed that the same project may be seen as significance or not significant due to different interpretations by members of the same research community.

3.5 Defensibility of outcomes

Lincoln and Guba (1985) suggest that the trustworthiness of studies with naturalistic underpinnings should be established through addressing their credibility, transferability, dependability and confirmability. Phenomenographic research is usually described as interpretative, rather than naturalistic. Nevertheless phenomenographers also need to establish trustworthiness within a phenomenological, rather than a positivist framework. Criticisms of phenomenographic research on the basis of lack of validity, lack of predictive power, researcher bias and denial of the voice of the individual through categorisation (Bowden 1995, p.145), have led to increased attention being paid to the need to establish the trustworthiness of the outcomes (Bruce 1994; Bowden 1995; Gerber 1993; Sandberg 1994, 1995a, 1995b). The trustworthiness of the outcomes of this study is based on approaches established by Saljo (1988), Gerber (1993) and Sandberg (1994, 1995a). The thinking of each of these researchers contributes to an understanding of what is required to ensure sound outcomes of a phenomenographic study. Outcomes of a phenomenographic study could be said to be sound where:

- there is a demonstrable orientation towards the phenomenon (in this case the significance and value of IT research) through the process of discovery and description

- they conform to the knowledge interest of the research approach, in this case interest in the appearance of the phenomenon
- they are communicable.

The trustworthiness of this study was established through meeting the above criteria.

3.6 Participants

This section summarises the profiles of the research participants who were interviewed. Participants were selected to maximize the possibility of eliciting different ways of conceiving the value and significance of particular kinds of IT projects.

Table 1: Profiles - Researcher participants

Gender		Age				Sub-discipline				Research experience			
M	**F**	**<30**	**31-40**	**41-50**	**51+**	**CS**	**IS**	**DC**	**IM**	**St**	**Ear**	**Exp**	**NA**
8	3	4	2	1	4	4	3	3	1	3	1	7	0

Key to abbreviations
Sub-discipline: CS = Computer Science, IS = Information Systems, DC = Data Communications, IM = Information Management.
Research experience: St = Student, Ear = Early Career, Exp = Experienced, NA = Not Applicable.

The eleven participants in this project brought with them a diverse range of perspectives, interests and experience. Eight were male and three female. In terms of their age, a majority were either over fifty or under thirty: four were under thirty years of age, two aged between thirty and forty, one between forty and fifty and four were over fifty years of age. There was a fairly even distribution over the sub-disciplines represented: four were from Computer Science, three from Information Systems, three from Data Communications and one from Information Management. The majority were experienced researchers: three considered themselves to be students, one was early in their career as a researcher (having completed their PhD in the last 5 years) and seven were more experienced researchers.

The participants' research interests were spread over areas like: the computer-human interface, information use, information security, and programming languages. Four of the participants were researching information security.

3.7 Ethics

Before the research project commenced ethical clearance was obtained from the University Ethics Committee. At the interviews participants signed a consent form indicating their willing participation in the project.

4 Mapping IT Researchers' Ways of Seeing Significant and Valuable Research

In all, five different ways (categories of description) of seeing significant and valuable research were uncovered. These ways of seeing are not intended to capture the views of individuals, in the sense that individuals cannot be aligned with any one of the categories. Each individual may be expected to adopt one or more of the ways of seeing in relation to a particular project at a particular point in time. The categories identified were:

1. Category 1: The Personal Goals Conception
   In this category significant and valuable research projects are seen as those which help the researcher attain their personal goals. The external horizon is the individual. The internal horizon (focus) is personal goals.
2. Category 2: The Research Currency Conception
   In this category significant and valuable research projects are seen as those which generate

research currencies. The external horizon is the research community. The internal horizon (focus) is research currency.

3. Category 3: The Design of the Research Project Conception
   In this category significant and valuable IT research projects are seen as those which are designed appropriately. The external horizon is the research community. The internal horizon (focus) is the design of the research project.
4. Category 4: The Outcomes for the Technology End User Conception
   In this category significant and valuable IT research projects are seen as those which serve people. The external horizon is humankind. The internal horizon (focus) is outcomes for the technology end user.
5. Category 5: The Solving Real-World Problems Conception
   In this category significant and valuable IT research projects are seen as those which address real-world problems. The external horizon is humankind. The internal horizon (focus) is solving real-world problems.

In some categories, the participants share the same perceptual boundary (external horizon). For example, Category 4 'Outcomes for the Technology End User' and Category 5 'Solving Real-World Problems' share the same perceptual boundary, namely 'Humankind'. The widening of the perceptual boundaries assists in locating each category within an outcome space. We argue that 'Humankind' is a wider perceptual boundary than 'The Research Community' and that 'The Research Community' is a wider perceptual boundary than 'The Individual'.

5 The Categories of Description

5.1 Category 1: The Personal Goals Conception

Significant and valuable research projects are seen as those which help the researcher attain their personal goals.

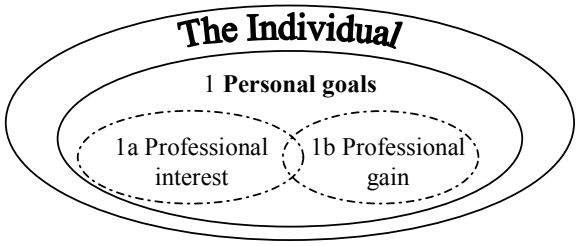

Figure 2 : Awareness structure for the Personal Goals Conception

The chief interests of IT researchers in this category are personal. They are fundamentally interested in the value or impact of the research project on themselves and/or on their research role. They are not concerned with the constraints on the project itself nor are they considering the results for humanity.

The awareness structure of this category is depicted in Figure 2. In this category IT researchers are not seeing beyond their own interests when considering the value of a research project. The individual, therefore, forms their perceptual boundary and is represented here as the external horizon of the category.

The focal element in this and remaining categories is composed of both stable and variable aspects. The stable component here is 'personal goals', with the varying orientations being depicted as either 'professional interest' or 'professional gain'.

In ***Subcategory 1a*** significant and valuable research projects are seen as those which interest the researcher. These projects may arouse the curiosity of the researcher or the researcher may find the research fun to be engaged in. The researcher also agrees with the use of the research outcomes.

> *I like to do it. (11.2b)*
>
> *... for me it's mostly curiosity ... (9.2b)*

> *... the research centre is actually structured with a number of sub-groups, so ... people have particular interests in different fields ... (7.2c)*

> *... in the end ... there are some [research projects] that I would ... criticise on the basis that it doesn't seem to benefit anyone except perhaps ... a military industrial complex or something ... the more pejoratively you think about that community, then, the less interest you would have in it ... somebody develops some really specialized weapon ... and ... you think, "Well ... I don't like them." (3.4b)*

> *One thing I don't like, I suppose, is ... they do it for short-term commercial interest and a lot of times ... well, too many times, it's done just because, "Hey, this is something that we can do and we can sell and the other guy's already got the patent or so on it, he's got the better system, but we can sell ours instead." ... so we get an inferior product coming out ... the better thing gets squashed for a while ... I don't like necessarily the ... commercial influence in research ... a lot of times they're not the best of people ... (7.10a)*

In ***Subcategory 1b*** significant and valuable research projects are seen as those which contribute positively to the researcher's own career and research. These research projects help advance the researcher's own research projects or work in some way.

> *... you would probably judge something as insignificant if it doesn't contribute ... to your job ... in teaching or if it doesn't advance in some way your career. (11.3b)*

> *... it depends on what you're trying to do as to what is significant for you ... if your aim is to write a program to sell to Queensland Rail to schedule their train drivers, you're not interested in information systems ... of ... modelling their company to ... suit their accounting system or something like that. You're interested in writing this program to deliver to them to sell to them and that's it ... (8.6c)*

Interrelation of the viewpoints

Financial considerations were seen to be more pressing than interest by one researcher:

> *I guess the money is sort of pretty important in these things, even if someone might like something else that's more interesting ... (7.3b)*

In fact, financial considerations could determine significance according to another participant:

> *... what's considered significant or valuable is very much led by the nose which is called 'funding'. Like if someone wants to give you half a million dollars to investigate improving protection, then that's what you investigate and that's a significant project ... can you deny that? (3.2d)*

In contrast, another researcher considered interest of prime importance:

> *... you really have to look at it and see that you are interested in it, because otherwise research is long-term and it is very difficult to sustain if you're not interested in it, regardless of whether it is very significant or it earns a lot of money ... (1.3c).*

These competing needs are seen to act upon each other dynamically by another researcher:

> *... I think there is an interplay between what the team members intellectually would like to do and find interesting and what is meaningful for them in terms of their career and the job to do. (11.3b)*

5.2 Category 2: The Research Currency Conception

Significant and valuable research projects are seen as those which generate research currencies.

Figure 3 : Awareness structure for the Research Currency Conception

The chief concerns of IT researchers in this category have to do with the extent to which research projects are able to generate research currency, such as promotions, grant applications and publications. They are concerned with how the research project adds value to the research community. They are not necessarily considering their own needs or the needs of humankind in general.

The awareness structure for this category is depicted in Figure 3. In this category, researchers are seeing research currency from the point of view of the value it holds for the research community. The research community, therefore, forms their perceptual boundary and is represented here as the external horizon of the category.

The stable component here is 'research currency', varying orientations did not appear in the data.

In this category significant and valuable IT research projects are seen as those which benefit the research community by providing funding for the employment of researchers or enabling a research centre to continue to exist. They may be producing publications, providing grant money, enhancing group status, promoting colleagues or leading to further work.

> *... it enables us to get some useful publications in the same field ... (7.2b)*
>
> *I think that most people would expect a significant project ... would lead to further work, or would lead to further publications and particularly acceptance ... at conferences which were considered to be ... fairly top-level type conferences ... and would be leverage ... for further funds and further work. (7.3a)*
>
> *... at the moment it gives us money to employ researchers or to continue employing researchers whom we have been employing ... (7.2a)*
>
> *One of the recipients was very honest ... he had a project, 2 million marks or something ... and he stood up and said, "Well, I think it was very successful, this project - as a result we have three professors, they got their chairs because of it" and I think that was straight to the point, it told the truth ... (11.4c)*
>
> *... this one is going to lead to other things, other research ... (7.5d)*
>
> *... most of these things haven't produced major advances ... it's ... not wasted money because it keeps the exercise of research going ... (11.4b)*

5.3 Category 3: The Design of the Research Project Conception

Significant and valuable IT research projects are seen as those which are designed appropriately.

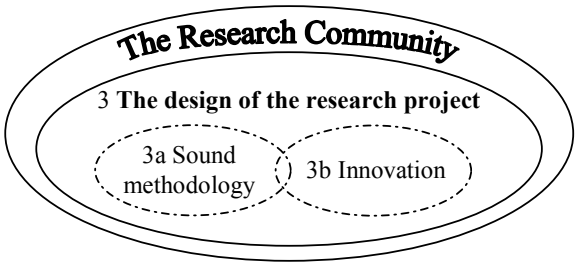

Figure 4 : Awareness structure for the Design of the Research Project Conception

The chief concerns of IT researchers in this category have to do with the research itself. They are interested in the nature of the project and its validity as research. They are not concerned with their own needs nor are they considering the needs of humanity.

The awareness structure of this category is depicted in Figure 4. In this category, as in Category 2, IT researchers are not seeing beyond research itself when considering the value of research projects. The research community, therefore, forms their perceptual boundary and is represented here as the external horizon of the category.

The stable component here is 'the design of the research project', with the varying orientations being depicted as either 'sound methodology' or 'innovation'.

In **Subcategory 3a** significant and valuable IT research projects are seen as those which are designed appropriately. These projects are seen as those which follow recognized research methodology. They are conducted by respected researchers. They require considerable intellectual input. They have clear direction, with a solution in sight. They are able to be validated or believed. They draw on a breadth of participant base or are widely applicable. They acknowledge previous research. They break away from funding/commercial imperatives. They follow research trends, interests or traditions.

> *It has to be methodologically sound, you have to apply your scientific method ... there is a whole lot of theory about ... how you proceed in finding ... new knowledge ... (11.5a)*
>
> *... what actually makes it important is the design of the research program to be fairly all-encompassing ... trying to maintain a consistent theme across all the projects while allowing academic and research freedom ... (6.2b)*
>
> *... the really good work done in such areas is stuff that can be validated in different environments ... (10.4a)*
>
> *... you always look at the track records of the people involved and see ... how well their backgrounds align with the problems they are looking at ... (4.5b)*
>
> *... industry tends to ... ignore a lot of the more theoretical work ... or they [are just not] into stuff that may not be relevant, so I think that it is something that should be explored ... (5.2c)*
>
> *... whether they've done a proper literature review of the area, whether they understand the solutions that are currently present sufficiently ... and whether they show at least ... if they show adequately that these currently proposed solutions do not solve the problem ... (4.5a)*
>
> *... research by its very nature takes a much longer time to complete and to justify than ... the users in the IT industry of today ... [are] ... prepared to commit. (6.7b)*

In ***Subcategory 3b*** significant and valuable IT research projects are seen as those which explore new frontiers where projects add to previous research. The element of innovation present in the research may be in breaking new theoretical ground, in taking a new approach to a long-standing problem or in a contribution made to the existing knowledge base. An element of risk of failure accompanies such endeavours. Difficult questions/problems may be confronted or speculative endeavours engaged in.

... you have to make a contribution to the knowledge base, so I think you have to give some new knowledge in some sense ... (8.4c)

... it's a novel way at looking at an important problem ... (3.3a)

... if they're actually coming up with some theory ... (5.7a)

This would further humanity's knowledge and ability ... to ... go into fields ... where people haven't been before ... (7.3c)

I believe of all the groups ... we are probably doing the cutting edge ... stuff rather than ... more of the same ... (9.3c)

I think as long as you ... answer some significant questions. To me a significant question is one that either ... no one [has] asked that question ... or the question is so difficult that no-one dares touch it and you're trying to answer it. (9.9b)

... I believe that academic freedom is all about being able to follow your own clues ... (9.2c)

... it's going to require some significant ... intellectual contribution in solving it ... (9.7d)

The more speculative the approach, the less predictable the outcome is likely to be:

Reminds me of the old story ... the guy that comes home and his wife is waiting ... and ... on the way home he ducks into the pub and he drinks another one and another one ... and in the end he is completely drunk ... eventually he can hardly drag himself, so ... he walks home and he gets there, he can't open the door ... he lost the key, so he goes back looking for the keys. Two in the morning, she gets up, he's not there yet, she went looking for him, so she finds him on the way from the pub, half way there, and he's standing under the lantern in the street, he's looking around the ground. She said, "What are you looking for?" He said, "I lost the key." She said, "Are you sure it's here?" He said, "No, but it's the only place where there is light." It's a very nice and old story and I think that a lot of the research is done where there is light and that's a real problem. It's easy, there's a lot of literature ... it's very easy to get started. Everybody tells you where the coalface is ... one of the problems is people go and try and solve problems and they're all working on the same problem and usually ... not difficult ones either because ... people like to work on problems where there is a solution that's in sight ... it's quite clear from the outset you are not wasting your time because there's going to be an outcome and you know what the outcome ... is, you know what you have to do to get it and even though you're not sure what the tables or the graphs will look like, that's the information you're after, you know that it's going to be there and while what we do is much more speculative ... if you do find something it can be very significant ... but ... it doesn't have to be apparently significant. It can be apparently insignificant, that doesn't matter ... (9.3d)

Interrelation of the viewpoints

For some participants significant research requires clear definition:

... research should be more directed and focused. (2.5a)

... it seems do-able ... (3.9c)

... if you say, "Ok I have a goal, I have this vision of what we could do, and I need this and this bits and pieces" then that gains some relevance in relation to that goal ... we can certainly say that something is irrelevant if we are doing it without having a further goal. (11.7c)

For other participants significant research is a process of discovery:

... the potential for finding things along the way ... (9.7d)

... that kind of problem I'm more attracted to because that's one where you really don't know what you're going to find and it may fail, ok, so it's not clear. I like more risky, more speculative research ... (9.6a)

... I think that this kind of research is gonna find something that everybody who tried it would find the solution for, so again it's a ... to me, this is probably the least valid even though this might be mainstream ... research. (9.7a)

Sound methodology and innovation are seen to exist in tension with each other. Sound methodology demands the discipline of working within guidelines, whereas innovation tends to want to exercise freedom:

> *... as an academic I believe that academic freedom is all about being able to follow your own clues and ... of course, it's not open slather ... do what you like ... but within a very ... broad area of IT there is so much you can research without belonging to any particular pigeon hole ... (9.2c)*

> *... what actually makes it important is the design of the research program to be fairly all-encompassing ... trying to maintain a consistent theme across all the projects while allowing academic and research freedom, which is important in any large research project where you've got multiple people working on it - my strategy, anyway, is to get the best out of those people we have to have academic freedom while at the same time trying to apply some loose form of guidance or control to keep people thinking along the same lines ... there still needs to be that degree of academic freedom to get the best out of them, to get the most valuable research ... (6.2b)*

> *... if I'm assessing a project for viability ... what it's trying to achieve, the scope of what it's trying to achieve, the realisticness of what it's trying to achieve, also to me plays a part in its significance ... it can't be too ambitious but at the same time it can't be too trivial. (6.5b)*

5.4 Category 4: The Outcomes for the Technology End User Conception

Significant and valuable IT research projects are seen as those which serve people.

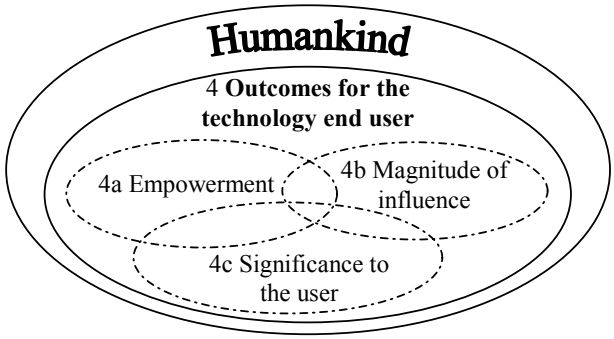

Figure 5 : Awareness structure for the Outcomes for the Technology End User Conception

The focus of IT researchers in this category is on benefits to the end user. They are interested in the positive results of the project on people, not how it benefits themselves as individuals or the research community nor whether it finds solutions.

The awareness structure of this category is depicted in Figure 5. In this category IT researchers are seeing the end user in the context of the benefit the research offers to humanity, therefore humankind forms the perceptual boundary and is represented here as the external horizon of the category.

The stable component here is 'outcomes for the technology end user', with varying orientations being depicted as 'empowerment', 'magnitude of influence' and 'significance to the user'.

In ***Subcategory 4a*** significant and valuable IT research projects are seen as those which enable people to live or work better together. These projects make it possible for people to use technology more easily or to manage information more skilfully, thus improving on current practice. In this view, significant and valuable research is seen as research which enables technology to adapt itself to people, reducing the necessity for people to adapt to technology. Significant and valuable research projects are seen as those which are commercially viable. They save money. They contribute to the economy. Significant and valuable research projects find solutions to humanity's problems. They are viewed from the point of view of the improvement of life for humankind.

> *You want to push the technology so that it serves people in the most intuitive and flexible way. (1.2a)*
>
> *... things have to be real-time adapting and allow people to collaborate with each other. (1.2c)*
>
> *It ... also can be significant in the sense of changing the way people think about things - the way people work and also think ... to improve things. (1.2d)*
>
> *... something that ... contributes to the betterment and well-being of - the improvement of life for man ... that would be ... significant and of value. (2.3a)*
>
> *... it's all about making information work better for you ... (10.2b)*
>
> *... its solution would benefit people besides yourself. (3.4a)*
>
> *... my whole research endeavour has been user-driven ... rather than ... doing things for their own sake, I've always done things where I think people ... can make use of them ... in other words, a lot of it is because it's been asked for ... (10.5b)*
>
> *... this is an important area ... it would benefit a lot of people, because enormous amounts of money are spent on rewriting systems ... (3.9b)*
>
> *... it will reduce development time and expenses for actually building software ... (5.1d)*

Interrelation of the viewpoints

One researcher considered this element to be fundamental to significance, in contrast to sound methodology (Category 3a):

> *... a project that is significant or valuable will have to be useful, will have to be relevant, not necessarily rigorous by itself. (2.3a)*

Economic viability is seen by another as being linked with usability in the marketplace (see also Subcategory 5c):

> *... he approached it from a very commercial point of view ... almost from a business management point of view ... and that's really important because if we come up with some whiz-bang ideas, if it's not going to be integrated into actual practice then it's not going to have any impact eventually. (5.2d)*

This element was seen by one researcher as justifying the reception of public money for research:

> *... I do think you're not justified in taking public money unless you can demonstrate a benefit. (3.11c)*

Others see the impact of commercialisation on research as being negative:

> *... the IT industry moves fast and when there's a problem they want it solved today. They want a solution that they can make available to the customer today and because of that we are seeing substandard solutions with problems ... research by its very nature takes a much longer time to complete and justify than ... the users in the IT industry of today is prepared to commit. So I think that's one of the big challenges of IT research – convincing industry, convincing the community, that to do things right you can't have a solution today. (6.7b)*
>
> *One thing I don't like, I suppose, is probably the ... dominance of ... short-term commercial interest and a lot of times ... well, too many times, it's done just because "Hey, this is something that we can do and we can sell and the other guy's already got the patent or so on it, he's got the better system, but we can sell ours instead". And ... so we get an inferior product coming out ... so the better thing gets squashed for a while ... I don't like necessarily the ... commercial influence in research ... a lot of times they're not the best of people ... (7.10a)*

To one researcher empowering human beings and solving problems (Category 5) are synonymous:

> *... you can ask an engineering problem and say, "Well, will it make life easier for me, will it solve a problem?" (11.5b)*

In ***Subcategory 4b*** significant and valuable IT research projects are seen as those which impact greatly on people. These projects are seen as making a considerable positive contribution to humanity, either by

influencing directly the lives of people or by providing building blocks with which such advances may be constructed in the future. These research projects may be seen as having a breadth of applicability so that they serve the largest possible body of users. Such projects may also span disciplines and have an integrative approach. Other projects are considered significant because of the length of time over which they extend their influence.

> *... we look for something which is going to assist a lot of people ... (7.6c)*
>
> *... the idea of size comes into it ... the narrower the community the less interest you would have in it ... (3.4c)*
>
> *... world-changing ... world impact ... very few projects can actually achieve that but if it can often make steps towards that, that's important. (6.5c)*
>
> *... it is important because you find applications in many areas ... (4.7d)*
>
> *... it covers a number of different aspects, it uses different techniques ... it's not just one single tool or one single main idea, it has to relate to many things, it may apply to different ... practical problems ... in the process of research you are generating some new knowledge ... if that knowledge is only applicable at the moment, or you can envision only it to be applied in certain specific select cases, or a certain selected domain ... then I think it is not a rich ... but when you can come up with different possible applications it sort of generates different ideas, you use a range of tools, then ... it's like if you only run 400 metres as a runner, that's very specialised, but if you run 100 metres, 400 and 5k then ... you've covered a better range of things, you get a better appreciation of how things relate. (11.2c)*
>
> *... I think they [the branches of IT] have more value if they can work complementarily ... unless one can actually integrate many things together ... the value of it is a lot less ... the world is increasingly requiring integration. (1.7b)*
>
> *To my mind, something that is really significant will have a long-term impact ... (6.4c)*

In ***Subcategory 4c*** significant and valuable IT research projects are seen as those which serve specific groups of people. These research projects are seen as conducting research which meets the needs of particular sub-groups of society, even if they do not directly benefit the wider community and even if the researcher is not part of that subgroup. Examples of these subgroups are analysts, professionals and educators.

> *... its significance is that it helps analysts ... (4.2c)*
>
> *You can investigate the problem to see whether it can be done or not ... you don't need to have the assumption that if it doesn't work that means your work is no longer valid - at least that we know that that particular way doesn't work ... but of course one wants to be able to find a way that it works, so the priority is to find that but if you collect a lot of information so that other people who follow you know that this line of thought has all these problems, then it is quite useful, too. (1.3b)*
>
> *... the significance of pure research is its usability ... after it has been completed ... are experts in the field going to look at it and say, "Yes, we can make use of this knowledge in our own work"? So, to me pure research - significant pure research - impacts on other researchers, not on the community as a whole, but on other researchers who are in that narrow area. (6.5d)*
>
> *... the people that are asking ... tends to be only the 'profession' ... people who are interested in the ongoing development of a group of people interested in a particular area with a set of ethical, professional constraints and things applied ... the only kudos there is ... professional support ... (10.5c)*
>
> *... a lot of research which doesn't have obvious application has the application of informing education better ... to me the fundamental reason for academies is education ... (10.6d)*
>
> *... if we're exercising our critical thinking, our inventiveness, our skills and using tools ... and I think that's relevant if it enhances our capacity to transmit that knowledge to students, I think that's relevant and that's justified ... justifies it. I think from the point of view of the university and the society, I think that's the function research has to fulfil. (11.8a)*

5.5 Category 5: The Solving Real-World Problems Conception

Significant and valuable IT research projects are seen as those which address real-world problems.

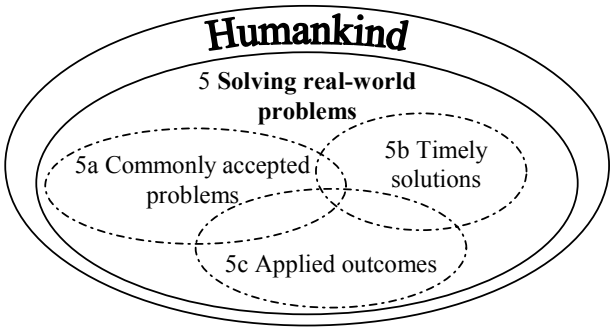

Figure 6 : Awareness structure for the Solving Real-World Problems Conception

The chief concerns of IT researchers in this category have to do with finding solutions to problems. They are not considering their own needs, they are not concerned with the research community, nor are they considering the result for the IT end user.

The awareness structure of this category is depicted in Figure 6. In this category IT researchers are looking beyond their own world and at the influence of the research on humanity when considering the value of a research project. Humankind, therefore, forms their perceptual boundary and is represented here as the external horizon of the category.

The stable component here is 'solving real-world problems', with the varying orientations being depicted as 'commonly accepted problems', 'timely solutions' and 'applied outcomes'.

In ***Subcategory 5a*** significant and valuable IT research projects are seen as those which address real-world problems. These projects are regarded as dealing with problems that have been identified by a number of people. The problems dealt with are known, accepted, identified and long-standing.

> *... the reason why ... projects within the research area are significant is because all the projects ... address identified and immediate problems. (6.3a)*
>
> *... if it actually solves a problem ... I would consider research valuable if they did that as well. (4.8b)*
>
> *It should ... seek to solve problems, if not, identify the problems so that people can solve it for the future. (2.3a)*
>
> *... it's a known problem ... (3.3d)*
>
> *... the reason I see it as highly significant is ... in practice people are confronted with the problem ... (4.2c)*
>
> *... that's important because ... we still have a problem ... (9.5b)*
>
> *... it's looking at a fundamental problem that we don't have a solution for ... (9.6a)*

Interrelation of the viewpoints

To one participant funding availability indicates what is of interest to others:

> *... I've always done things where I think people ... can make use of them ... in other words, a lot of it is because it's been asked for ... or ... there has been money available to pursue specific areas which, in a sense, is asking for it, by people who hold purse strings being able to say ... we think this is worth following ... (10.5c)*

However, this influence is not seen as being entirely positive:

> *... obtaining grant money is also important but that in itself is problematical because ... despite what I said earlier about grant money being some indication of what people wanted done, it often forces ... people to constrain themselves ... and particularly to report on research projects*

> *in such a way that I think it inhibits the research projects ... you're spending your time reporting according to constraints ... you're spending your time with bureaucratic stuff ... (10.8b)*

In ***Subcategory 5b*** significant and valuable IT research projects are seen as those which find timely solutions. These projects are up-to-date. They are completed before the problem addressed becomes a non-issue. The problems they concentrate on are of immediate interest. They follow trends with respect to academic interest and with respect to end-users' needs and anticipated demands.

> *It should be time-dependent ... it shouldn't be looking at something that was done years ago and trying to redo that, when it has no significance to the future or the present at all. (2.4a)*
>
> *... it needs to be timely. There needs to be ... a bit of foresight, a bit of ... prediction as to where the demands or where the industry is going to be in a few years' time ... you've ... got to solve problems that you believe are going to be problems by the time they're solved. (6.5a)*
>
> *I can also see a lot of interest generating in this field particularly in journals and publications that are publishable this year, especially this year. (2.2c)*
>
> *... its significance is that ... it can be applied in an educational situation immediately ... (5.5c)*
>
> *... research into graphics is incredibly important because that's where all the movement is taking place and that's what's sucking people into information technology. (3.8b)*
>
> *... component programming is sort of touted as the next big step in software engineering ... (5.1a)*

In ***Subcategory 5c*** significant and valuable IT research projects are seen as those which result in an application in a real-world context. Even 'pure' research's significance is seen in the light of what future use it can be to those searching for the solutions to problems. According to this view, solutions found in research must eventually be implemented in order for that research to be significant.

> *... it has to have a real world application ... everything has to be for something ... (8.3d)*
>
> *... information technology is an engineering discipline ... we are in the business of creating applications, of using the knowledge to produce useful gadgets, artefacts, programs, whatever ... (11.6b)*
>
> *I necessarily wouldn't judge a research project as useless if it didn't provide some type of immediate practical gain ... projects ... that are not necessarily going to be applied now but maybe in 20 years time there'll be some type of physical process which we discover actually follows that type of behaviour ... and even if it's not actually ever applied, research can generally be built on and ... if someone refers to that research maybe they'll be able to build something with it ... (5.6b)*
>
> *... you could well argue I think that this is important practical material because it will lead to important practical things later on ... (7.5b)*
>
> *... he approached it from a very commercial point of view ... almost from a business management point of view ... and that's really important because if we come up with some whiz-bang ideas, if it's not going to be integrated into actual practice then it's not going to have any impact eventually. (5.2d)*

Interrelation of the viewpoints

For one of the researchers, the issue of application was the central one, more important than innovation (Subcategory 3b):

> *... nothing in IT has been worth researching unless it could be implemented. There's no novelty that is worth it unless ... a program gets written or ... an information collection gets made ... (3.10c)*

For another, the issue of timeliness was more central than that of interest (Subcategory 1a) and although finding a solution was important, timeliness was necessary as well:

> *... it may be the most interesting thing, but is it really significant, if it's interesting but gets left on the shelf for the next ten years after it's completed? I don't think so ... if it's applied, not only does it need to be solving a problem, but it needs to be timely. (6.5a)*

6 Outcome space

The five categories described above may be interrelated to form an outcome space. Key components of this outcome space are depicted in Table 2.

Table 2 : Key components of the researcher participant outcome space

External Horizon	**Internal Horizon, Fixed component (Focus)**	**Internal Horizon, Variable component (Elements of focus)**
Name	*Cat# Name (Report Section)*	*Subcat# Name*
The individual	1 Personal goals (5.1)	1a Professional interest
		1b Professional gain
The research community	2 Research currency (5.2)	
	3 The design of the research project (5.3)	3a Sound methodology
		3b Innovation
Humankind	4 Outcomes for the technology end user (5.4)	4a Empowerment
		4b Magnitude of influence
		4c Significance to the user
	5 Solving real-world problems (5.5)	5a Commonly accepted problems
		5b Timely solutions
		5c Applied outcomes

The graphical depiction of the relationship between the categories is presented in Figure 7. This depiction shows the widening perceptual boundaries associated with Categories 1 and 2/3 and 4/5. The outcome space constitutes an experiential framework for thinking about the significance and value of IT research projects amongst IT researchers.

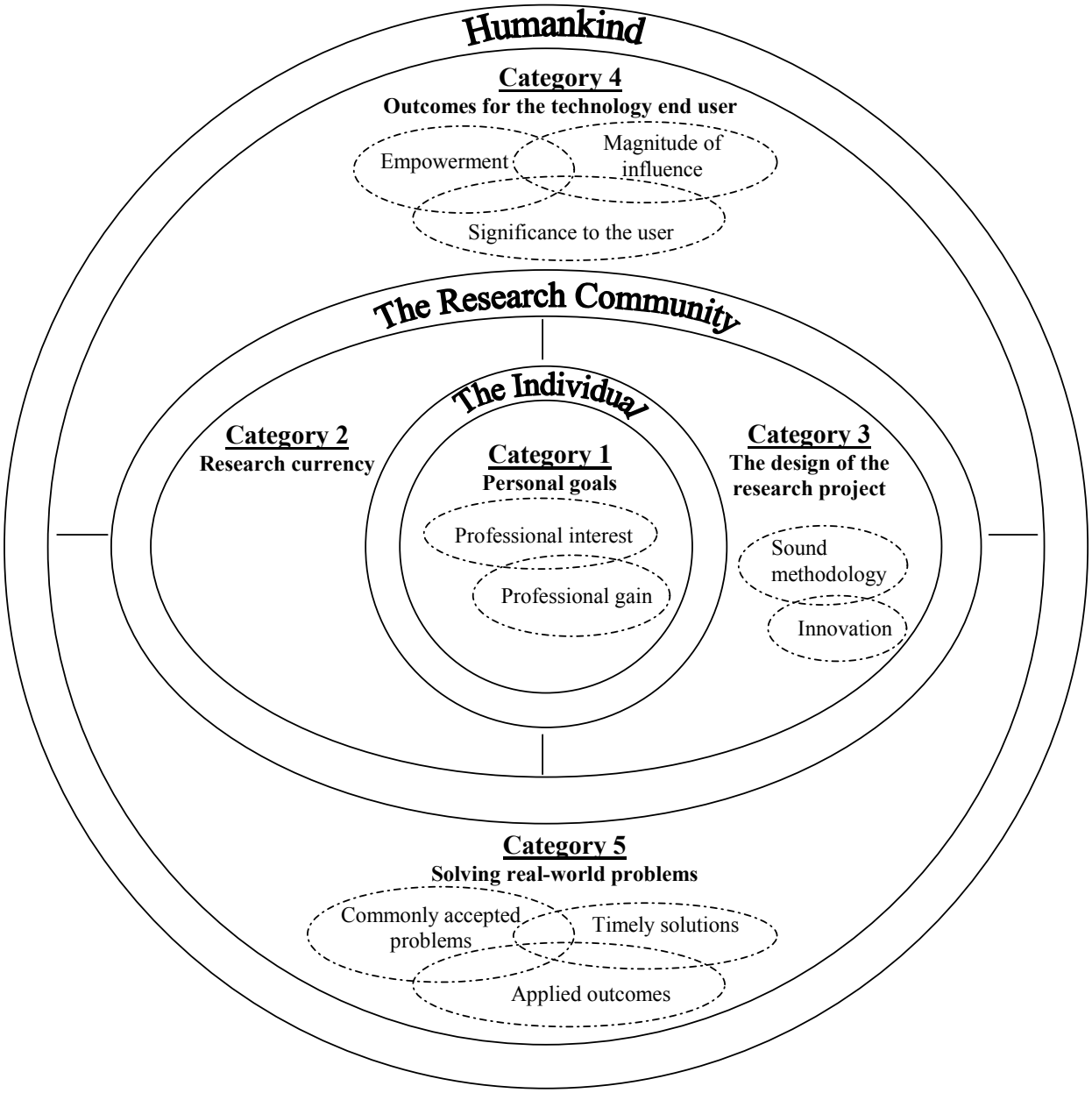

Figure 7 : Graphical representation of outcome space

7 Discussion

7.1 Potential use of these results

This project was supported by the National Office of the Australian Computer Society and the Research Office of QUT's Faculty of Information Technology; the latter being the location of a significant group of information technology researchers in Queensland. Project outcomes could be useful at both the Faculty and University levels for development of strategic directions, to facilitate collaboration with researchers from other disciplines and industry, and to establish cooperation between faculty based research groups. The project, which is part of a new global research direction that is in its earliest stages, will act as a feasibility study for a larger inquiry that will add breadth and depth to the investigation. The project also serves as a precursor to a wider investigation of the different ways in which information technology researchers from different subdisciplines construct their research domain.

This analysis provides a picture of ways of seeing significant and valuable research projects amongst IT researchers.

1. The outcomes reveal different ways of seeing significance and value that may need to be understood by participants in collaborative projects.
2. The outcomes are also available for comparison with the picture drawn of the ways of seeing significant and valuable IT research projects amongst IT industry professionals, as revealed in another part of this research project (see below).
3. We may hypothesise that collaborative projects are more likely to be developed by research partners who either share the same ways of seeing significance and value or who understand and are sympathetic towards each others' ways of seeing.

7.2 Category 2

There is clear evidence for Category 2, 'Research currency', however the current study was not able within its resource limits to pursue the breadth of this category sufficiently.

7.3 The place of 'knowledge'

It was felt by the authors of this report that perhaps 'knowledge' ought to be explicitly positioned somewhere within the analysis, however it was not clear exactly where it belonged. Knowledge seems to be integral to research and a fundamental motivator for involvement in research. It also is one of the keys to power and competitive success.

> *... in the process of research you are generating some new knowledge. (11.2c)*
>
> *I think you have to give some new knowledge in some sense ... (8.4d)*
>
> *... it contributes to the big pile of knowledge, where some entrepreneur, some people, might dig in and pull out something that then becomes a commercial success. (11.8)*
>
> *... the significance in our university context boils down that ... we find a topic where we can exercise our thinking, our productivity and the development of the knowledge so that we can actually transmit it to students at the undergraduate and postgraduate level ... (11.1d)*
>
> *... if we're exercising our critical thinking, our inventiveness, our skills and using tools ... and I think that's relevant if it enhances our capacity to transmit that knowledge to students, I think that's relevant and that's justified ... justifies it. I think from the point of view of the university and the society, I think that's the function research has to fulfil. (11.8a)*

It is not clear if, in the researcher view of IT research, advancement of knowledge is sufficiently covered under Subcategory 3b Innovation. It is also possible to consider that knowledge pervades the whole of the outcome space. More research is needed to elucidate this aspect of IT researchers' ways of seeing IT research.

7.4 Ethics in IT research

In a similar discussion to that of 'knowledge' (above) the authors wondered where ethical conduct should be positioned in the analysis. A number of participants alluded to it and it seems to be an aspect integral to IT research.

> *I don't like necessarily the ... commercial influence in research ... a lot of times they're not the best of people ... (7.10a)*
>
> *... the more pejoratively you think about that community, then, the less interest you would have in it ... somebody develops some really specialized weapon ... and ... you think, "Well ... I don't like them." (3.4b)*

This could be seen to be a concept which permeates all categories, or it may fall within an additional subcategory under Category 4 Outcomes for the Technology End User. Further research is needed to explore this aspect of IT researchers' ways of seeing IT research.

7.5 Comparison of researcher/industry views

Table 3 begins to show the complementarity and commonality between the researcher and industry groups.

Table 3 : Comparison of Research and Industry Views

	Researcher		Industry
The Individual	1 Personal goals	The Individual	1 Personal goals
	1a Professional interest		1a Professional interest
	1b Professional gain		1b Professional gain
The Research Community	2 Research currency	The Enterprise	2 Commercial goals
			2a External operations
			2b Internal operations
	3 The design of the research project	Society	5 The design of the research project
	3a Sound methodology		5a Sound methodology
	3b Innovation		5b Innovation
Humankind	4 Outcomes for the technology end user		3 Outcomes for the technology end user
	4a Empowerment		3a Empowerment
	4b Magnitude of influence		3b Magnitude of influence
	4c Significance to the user		3c Significance to the user
	5 Solving real-world problems		4 Solving real-world problems
	5a Commonly accepted problems		4a Commonly accepted problems
	5b Timely solutions		4b Timely solutions
	5c Applied outcomes		4c Applied outcomes

On the whole, there are similar ways of seeing in both the researcher and industry groups.

A unique category for the industry participants is 'Commercial goals', in the context of 'The Enterprise'. However, it could perhaps be argued that aspects of the researchers' 'Research currency' category align closely with aspects of the industry 'Commercial goals' category. Thus, the two groups' ways of seeing in these categories may have much in common with each other.

On the other hand, even though 'The design of the research project' is a category both groups have in common, for researchers it is seen as lying within the context of a narrower perceptual boundary than

that of the industry participants. Thus, although they share the category label, their differing ways of seeing that category may have ramifications with respect to what each group sees as priority.

7.6 Researcher emphasis compared with industry emphasis

While the number of participants in the project was not sufficient for statistical analysis, we have made some attempt to discuss comparative emphases on the different categories of description.

Within the researcher participant group not all categories of description were referred to with equal frequency. The emphasis given to different categories by IT researchers, as indicated by the data collected in this project, is depicted graphically in Figure 8. This represents the tally of the number of times a particular way of seeing was expressed in the course of the interviews.

Amongst researchers, the category of 'The design of the research project' was mentioned most often, being represented in 38% of the relevant quotes extracted from the data. The second and third most frequently mentioned categories indicating significance and value were 'Outcomes for the technology end user', indicated in 28% of the quotes, and 'Solving real-world problems', indicated in 21% of the quotes.

The two remaining categories of ways of seeing were 'Personal goals', with 7% of the quotes and 'Research currency', with 6% of the quotes.

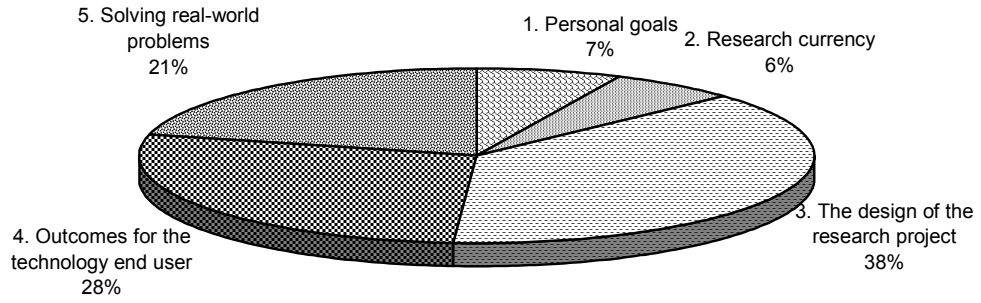

Figure 8 : Researcher participant category emphasis

The emphasis given to different categories by IT industry professionals, as indicated by the data collected in this project, is displayed diagrammatically in Figure 9. The category of 'Corporate goals' was mentioned most often, being represented in 42% of the relevant quotes extracted from the data. In terms of frequency of use, there was a wide margin between this and its closest rival, which had less than half as many mentions. The second most frequently mentioned category indicating significance and value was 'Outcomes for the technology end user', indicated in 18% of the quotes.

The next two of the remaining categories of ways of seeing were almost equally represented, at 15% of the quotes for 'Personal goals' and 14% of the quotes for 'The design of the research project'. The least frequently mentioned category, at 11% of the quotes, was 'Solving real-world problems'.

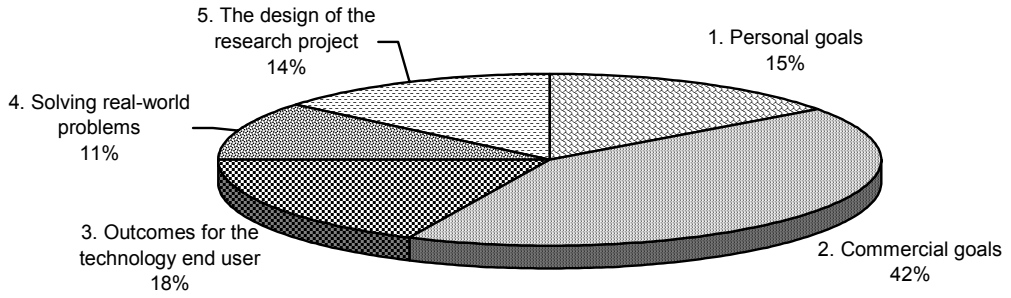

Figure 9 : Industry participant category emphasis

A comparison of the emphasis given to different categories by researcher and industry participants is represented in Table 4.

Table 4 : Comparison of Emphasis - Researcher and Industry Categories

Researcher Categories	%	Industry Categories	%
The design of the research project	38	The design of the research project	14
Outcomes for the technology end user	28	Outcomes for the technology end user	18
Solving real-world problems	21	Solving real-world problems	11
Personal goals	7	Personal goals	15
Research currency	6	Commercial goals	42

For researchers, 'the research project' receives the greatest emphasis, being mentioned 38% of the time, whereas for the industry participants this category is only mentioned 14% of the time. A possible explanation is that researchers are much more intimately involved with the research project. In contrast, industry emphasis lies with 'Corporate goals', at 42% of the quotes, perhaps revealing an acute awareness on the part of practitioners of the need for the organisation to survive financially.

It is difficult to gauge whether these percentages are a reliable measure of relative importance or interest, however the significant difference between the most and least mentioned categories is possibly indicative of the overall perspectives of these groups of people.

7.7 Recommendations for further research

Future study could address the following aspects of these results:

- We have depicted a broadening awareness in the outcome space, however is there a hierarchy of elements as well?
- We have attempted some analysis based on frequency of response, however a larger participant base would allow a rigorous statistical analysis of the results.
- We have limited our investigation to SE Queensland, however a broader study could include international perspectives.

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9 Appendices

The following documents are attached:

9.1 Letter of support from the Australian Computing Society

9.2 Abstracts used to stimulate discussion during the interviews

A • C • S
the society for information technology professionals

AUSTRALIAN COMPUTER SOCIETY IN
LEVEL 3
160 CLARENCE STREET
SYDNEY NSW 2000
AUSTRALIA
P.O. BOX Q534
Q.V.B. SYDNEY 1230
TELEPHONE: (02) 9299 3666
FACSIMILE: (02) 9299 3997
EMAIL: info@acs.org.au
INTERNET: www.acs.org.au

21 March, 2000

Dr Christine Bruce
School of Information Systems
QUT
GPO Box 2434
Brisbane 4001

Dear Christine

Re: Information Technology Research-a dimension of collective consciousness: differing ways of seeing the significance and value of research projects

I would like to indicate our support for your proposed project which aims to investigate variation in what researchers and industry 'end-users' consider to be significant and valuable contributions to the field of Information Technology (IT) research.

The Australian Computer Society (ACS) is concerned about the disparity in the perceived value of research in different sub-disciplines of Information Technology which has caused friction and fragmentation in the profession. Your study will benefit the IT profession in various aspects:

* Providing significant new insight into different forms of competence
* Facilitating interdisciplinary research as well as collaboration between different IT groups.
* Allowing researchers and industry partners to critique their own reasons for engaging in particular forms of IT research.
* Encouraging and facilitating technology transfer of research results to industry.

We wish you a successful project and shall appreciate if you can let us have a copy of your findings so that we can help disseminate them to the members of the Society.

Yours sincerely,

John Ridge

John Ridge FACS
President
Australian Computer Society

An Array Processor Architecture for Support Vector Learning

K. To†, C.C. Lim†, A. Beaumont-Smith†, M.J. Liebelt† and W. Marwood*
†CHiPTec, Department of Electrical and Electronic Engineering,
The University of Adelaide, SA 5005, Australia
*Communications Division, DSTO, SA 5108, Australia

Keywords: Support Vector Learning, Array Processor

Abstract

Support vector training requires the evaluation of a quadratic programming (QP) problem which is computationally intensive. In addition, the size of the QP is dependent on the number of training samples and may exceed the memory size. This paper presents a fast parallel implementation of the SVM on an array processor which is optimised for matrix operations. A decomposition algorithm is used to break large scale support vector problems into a fixed size block for efficient processing in the array.

1. Introduction

Support vector learning is computationally demanding to perform. Much of the processing is dominated by the inductive (training) phase. The support vector machine (SVM) inductive algorithm involves solving a positive definite quadratic programming (QP[1]) optimisation problem with a single linear constraint and box inequality constraints. SVM has been applied to classification, regression and time-series prediction of various size problems. The number of variables to be solved is equal to the number of training samples available. In practical applications, this can result in several thousand variables. As a result, SVM learning methods are considered more computationally intensive than many alternative learning methods. The single processor approach commonly used [6], does not have the necessary scalability to cope with the volume of data in large problems. Performance speed-up can be achieved by using parallel processing and appropriate software. This paper describes a new application of a decomposition algorithm on an array processor architecture for large scale support vector learning. The method of decomposition is based on [5]; and the array processor is the MarRISC processor [1] which is a RISC based architecture that is optimised for executing matrix operations.

2. Support Vector Machines

A support vector machine, in its simplest classification form, learns the linear hyperplane from training data by maximising the margin between two classes. It has been adapted to learn non-linear and non-separable distributed data and has also been applied to regression.

The SVM algorithm is based on Vapnik-Chervonenkis (VC) statistical learning theory, which describes the error bound between the *empirical risk* and *expected (true) risk* for a set of approximation function for a given set of data, $X = (\vec{x}_1, \vec{x}_2, \ldots, \vec{x}_l)$ belonging to the class $y = (y_1, y_2, \ldots, y_l)$. The approximation function with the lowest expected risk can be found by minimising the empirical risk and VC-dimension, according to the ***structural risk minimisation principle*** [2, 7]. More precisely, for a set of approximation functions f in a structure that consists of nested subsets of these functions,

$$S_1 \subset S_2 \subset \ldots S_k \subset \ldots$$

where the structure S_k has a *VC-dimension* h_k such that

$$h_1 \leq h_2 \leq \ldots h_k \leq \ldots$$

there exists a function where the sum of the risk bound and the empirical risk is minimised.

The SVM is an approximate implementation of the structural risk minimisation principle in that its objective is to maximise the margin of separation of a linear hyperplane by using an approximation function constructed from the weighted sum of a subset of the training sample set. These samples support the linear hyperplane in the feature space – hence the term *support vectors*.

The two phases of SVM learning are the training (inductive) and the testing (predictive) stages. They are now briefly discussed:

Training stage:

Consider a set of k classified example data for input to the SVM,

$$(\vec{x}_1, y_1), \ldots, (\vec{x}_k, y_k)$$
$$\vec{x}_i \in \Re^n, y_i \in \{-1, +1\}, \forall i \in \{1, \ldots, k\}$$

where $\vec{x}_i$ is the i^{th} input vector that belongs to the binary class y_i. The objective is to find a hyperplane $(\vec{w} \cdot \vec{x}) + b = 0$ by minimising the QP problem given by

$$\min_{\vec{\alpha}} L(\vec{\alpha}) = \min_{\vec{\alpha}} \frac{1}{2} \vec{\alpha}^T Q \vec{\alpha} - [1\ 1\ \ldots\ 1]\vec{\alpha}$$

subject to

$$\vec{\alpha}^T \vec{y} = 0$$

$$0 \leq \alpha_i \leq C, \quad i = 1, \ldots, k$$

[1] Also an abbreviation for the term quadratic program

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Business Process Reengineering
What are the social implications for the future if we continue to utilise IT to transform organisations?

Tracey Osborne
Griffith University, Australia

Executive Summary
What does the future hold for corporations as we approach a new millennium? According to Meel et al (1994) many organisations need to transform in order to maintain a competitive position within the market place. Industry trends have indicated that current or anticipated economic uncertainty has resulted in many organisations instigating changes to their current operations (Cascio 1993) to improve productivity, customer service, quality, speed and responsiveness within the organisation. But what impact will this have upon the workforce of the future?

Business process reengineering has been utilised as a tool to transform organisations, utilising the enabling characteristics of technology to achieve dramatic improvements in productivity and customer service on a wide scale. Advocates of BPR promote reengineering as empowering and enriching the workforce, whilst less enthusiastic proponents portray the deployment of IT in reengineering initiatives as a dehumanising process, whereby the principle objective is to maintain control over the workforce. The issue of integrating automatic control mechanisms into new systems is a controversial but pertinent issue for organisations of the future, as many corporations are reengineering their operations and developing new information systems.

The technological infrastructure is already available for organisation's to monitor most aspects of our daily lives, therefore, it is feasible that a panoptic[1] society that is overseen by a computerised office manager may become common place in reengineered corporations of the future. Although the author envisages the corporation that is capable of integrating control functions into processes whilst simultaneously enriching organisational life in the redesign process shall achieve a higher level of success and maintainable improvements.

Abstract
Since the conceptualisation of business process reengineering (BPR) in the late eighties and early nineties, interest in the topic has gained momentum, although very few authors have examined the impact upon the workforce and society. This research draws upon existing literature to examine the problems encountered by corporations in the mid 90's, the role of business process reengineering (BPR) and the utilisation of information technology (IT) in the transformation process. The paper also examines the deployment of IT in BPR to examine the impact upon the workforce, the implications for the organisation's social system and the anticipated effects upon employees in the future. The impact upon the workforce has been examined in relation to the effects of downsizing, and the impact of deskilling and controlling the workforce verses the potential to enrich organisational life.

1.0 Introduction
For organisations of the future change is imminent. Current trends have indicated that many organisations have already implemented wide scale changes. However, is this a result of organisational profiteering or has the need for transformation become a competitive necessity? Many organisations have implemented or are in the process of implementing business process reengineering, as the rhetoric promise of reengineering has been exemplified by examples of organisations achieving dramatic improvements in business efficiency and customer service on a wide scale. This paper has been developed by critically evaluating literature on IT, BPR and the social impact of change in relation to the present and future. The objective is to discuss the social implications for the future, if corporation's continue to deploy IT as a mechanism to reengineer the organisation.

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[1]Panoptic is Greek for 'all seeing'. The members of this type of society are the object of constant surveillance; they may be seen, but they cannot see (Foucault 1979).

Conceptions of an Information System and Their Use in Teaching about IS

Chris Cope, Pat Horan and Mark Garner
La Trobe University, Bendigo, Australia
C.Cope@latrobe.edu.au

Abstract

The question 'What is the nature of an information system?' is fundamental to developing and teaching about information systems, but it is the subject of debate in the IS literature and is not made explicit in most curricula. Our experience of teaching information systems analysis and design to undergraduate students has prompted us to seek better ways of developing students' understanding of the nature of an IS. Our study of IS users, practitioners academics and students, using the phenomenographic research methodology, revealed a hierarchy of four different conceptions of an IS. We have linked this hierarchy to the SOLO taxonomy (Structure of Observed Learning Outcomes) and used it to suggest teaching strategies intended to provide students with systems skills and understanding which will enable them to better interact with IS clients to produce good systems.

Keywords: Information systems conceptions, information systems teaching, analyst-client communication.

Introduction

What is the nature of an information system? This controversial question in IS research is central to the discipline, practice and teaching of IS. This paper considers and reports on:

- the need for IS practitioners and teachers to understand the nature of an IS
- the responsibility of IS education for the development of adequate conceptions of an IS in students
- a review of some of the reported research into the nature of an IS
- the results of an investigation into the conceptions of an IS held by a number of students, users, academics and practitioners
- strategies for assisting students to develop an adequate understanding of the nature of an IS.

We hope that the findings and ideas expressed in this paper will improve our teaching and our students' learning about the nature of an IS, resulting in better-prepared graduates and more informed IS practitioners.

Background

Effective analyst-client communication is crucial to system success. The most important outcome of requirements gathering is a shared perception of the system requirements (Tan 1994, Urquhart 1997). To achieve this outcome, Urquhart found that the analyst and client use interactional tactics (for example imagining and metaphors) in their conversations to facilitate conceptualization of the required IS. Poor communication is likely if the systems analyst is not competent at both interactional tactics and conceptualizing information systems (Urquhart 1997) or the analyst and client bring different conceptual frameworks to the conversations and these differences are not resolved (Tan 1994). Ineffective communication has been consistently related to user-dissatisfaction (Thorn 1995). End-user dissatisfaction is related to poor system utilization (Yaverbaum and Nosek 1992).

Although we recognize the importance of research into conversational techniques during requirements gathering, we are concerned with the problem of conceptualizing information systems. An inadequate IS solution is likely to be produced if a systems analyst:

1. has a poor understanding of the general nature of an IS, as this is likely to result in an inadequate conceptualization of the required IS and/or
2. lacks awareness that the client may have a different perception of the nature of an IS, as this can lead to inadequate communication.

So, where do systems analysts develop their understanding of the general nature of an IS and their awareness of the different perceptions held by their clients? Clearly, IS education has a responsibility to produce graduates who have an adequate understanding of the nature of an IS. We agree with Weber (1996) that most curricula fail to address this

Integration of Stereo and Shape from Shading Using Color

Darrell Hougen and Narendra Ahuja *
Beckman Institute
University of Illinois
405 N. Mathews Ave.
Urbana, IL 61801, USA
Ph: 217-244-4174
Email: hougen@uirvld.csl.uiuc.edu

Abstract. This paper describes a method for constructing a depth map that involves the integration of information provided by stereo with that provided by a shape from shading technique. This integration process is facilitated by the use of color images which are easily segmented. The integrated system is able to accurately obtain depth estimates under a wider range of conditions than either stereo alone or shape from shading alone.

1. Introduction

One of the central problems of computer vision is the estimation of three-dimensional surface shape. Several methods have been developed for solving this problem. Some methods, including stereo, use the information provided by the comparison of irradiance patterns from multiple images. Other methods, including shape from shading, use the information present in a single irradiance pattern to estimate shape. Until recently, little research has focused on combining these methods. However, there are significant benefits to be realized from an integrated approach to surface estimation [1,2,8]. In the present case, the use of color images facilitates the integration process.

One of the most widely studied of the comparison based methods of surface estimation is stereo [6,9]. It is well known that absolute depth can be accurately estimated for highly textured surfaces using stereo methods. However, small variations in surface shape cannot be recovered because of limits on the resolvability of densely spaced image features. Moreover, many real surfaces possess large featureless regions for which stereo methods are inaccurate. In addition, the relative accuracy of stereo decreases linearly with increasing depth [10].

Shape from shading is one of the most widely studied methods of estimating surface shape from a single irradiance pattern [7]. Unfortunately, it is difficult to obtain satisfactory results from images of real scenes without a good initial estimate of the surface shape, boundary conditions, and the light source direction. In addition, errors tend to accumulate across an image leading to large errors in global surface shape. Moreover, most real scenes do not satisfy the requirement that the albedo be the same everywhere.

Integrating stereo and shape from shading has several advantages [3,2,8]. The initial depth estimate provided by stereo can be used to provide the initial conditions, boundary conditions, and light source direction that are required by shape from shading, thus eliminating the need for human intervention.

Stereo systems can operate in highly textured regions and at the boundaries between different colored regions where shape from shading systems cannot operate. Conversely, shape from shading methods can be used in large featureless regions where stereo methods are inaccurate. Therefore, an integrated system has the potential of operating under a wider range of conditions than either stereo alone or shape from shading alone.

For stereo systems, errors in surface shape are locally large but are independently distributed so that global errors in surface shape are not cummulative. Conversely, shape from shading can be quite accurate in resolving small variations in surface shape if the boundary conditions are known. Therefore, integration presents the possibility of obtaining both global accuracy and high resolution.

In order for shape from shading to be useful in an integrated system, the problem of albedo variations must be addressed. In most real scenes, including those containing features that are useful for stereo vision, the albedo is not uniform. However, existing shape from shading algorithms require that the albedo be uniform. To circumvent this problem, it is assumed that the surfaces in the scene are composed of regions of piecewise constant color and albedo and can be described by a single reflectance function. Presently, all regions are assumed to have a Lambertian reflectance function. These requirements are actually relaxed by excluding the shape from shading algorithm from regions where the assumptions are invalid.

Based on the above assumptions, images may be segmented into regions of uniform albedo by segmenting them into regions of uniform color. Segmentation using color is more reliable than segmentation along gray level boundaries because color and albedo boundaries generally correspond to material boundaries but gray level boundaries often occur as the result of significant variations of surface geometry, e.g., at a bend or crease in a surface.

The rest of this paper describes a method for estimating surface shape that involves the integration of the informa-

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Re-Usability Of Legacy Software In An Object-Oriented Application Framework

François Gariépy & Lily Lam
ObjectForm Inc.
555 Dr. Frederik Philips, Suite 400
St. Laurent, Quebec H4M 2X4
CANADA
Tel.: (514)855-4970 Fax: (514)855-4971

ABSTRACT:

Computer-based simulation has become an essential tool for analysis, definition, evaluation and training in a wide range of fields. Faster deployment and broader use are hampered by the cost, time and the variety of advanced technical knowledge required to introduce simulation-based systems. Once the initial base class libraries are created, Object-Oriented analysis and programming increases the reusability of the components. Application frameworks further reduce the development cycle by embedding more domain knowledge in the framework and by promoting re-usability for classes WITHIN the framework. Reusability and life cycle reduction would have much greater value to organizations if a significant portion of inherited software could be reused in new software architectures.

This wealth of legacy software presents several challenges because of the indexing nature of the source language, the original operating system, its logical and data structure and its timing constraints. The focus of this paper is on the reuse, in a new object-oriented application framework, of FORTRAN-and-later source code developed following a top-down data analysis methodology for pseudo-real-time simulation applications. Although some generalization is necessary, three broad solutions are offered: (1) re-implementation in a true object-oriented methodology; (2) encapsulation in a reusable class shell; and, (3) integration as a foreign process.

This paper presents a pragmatic analysis of these solutions to help software engineers leverage legacy software in building a bridge that migrates towards true reusability. The key reuse decision factors are the intrinsic data/control partitioning, the modularity of the architecture, the data/control interface organization and the timing implementation. Each factor is analyzed to identify the criteria for selecting a solution and for minimizing the transition effort. Complete algorithmic re-implementation is ruled out because budgets and schedules generally make it impossible.

INTRODUCTION

The reuse of heritage software (or legacy software) is a major concern for any organization attempting to leverage existing software assets into new opportunities. For most organizations, the consolidation of heritage software with a productivity framework offers a distinct competitive advantage. The object-oriented environment provides the necessary productivity framework for many types of software system development projects. It offers several benefits to the user, including code reusability, life cycle cost reduction and a general improvement in quality. Unfortunately, the issue of heritage software reuse is not well addressed by this framework. A thorough analysis of the needs and requirements of using heritage software in an object oriented framework reveals several solutions.

UNDERSTANDING HERITAGE SOFTWARE

This difficult problem encompasses two main issues: (1) understanding the heritage software design and implementation and; (2) integrating dissimilar software code blocks. Unless a decision is made to reuse heritage software in its original environment and entirely independent from the object oriented framework, the spectrum of solutions require reverse engineering for program understanding.

In this era of software paradigm shifts, the decision to delay the introduction of new and more productive methods, such as object oriented design, may satisfy immediate schedule and cost demands but it is suicidal to the long term competitiveness of an organization. Instead, software architects should carefully analyze real synchronization and interfacing constraints applied to reintegration of heritage and create a hybrid solution that preserves some of the investment in software assets while taking full advantage of advanced frameworks.

Re-integration requirements involve reconstructing the structure of existing software and identifying the data, control and presentation. The software structure is a collection of artifacts used by software engineers when forming mental models of software systems. These artifacts include software components (procedures, modules,