FINAL REPORT

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

B. The Views of IT Industry Professionals

Christine Bruce

Binh Pham

Ian Stoodley

January 2002

Acknowledgements: This project has been supported by a QUT Scholarship in the Professions Grant and the Australian Computing Society.

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.

Phenomenological methodology is used to elicit data from a diverse range of IT industry professionals 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 Commercial Goals Conception, The Outcomes for the Technology End User Conception, The Solving Real-World Problems Conception and The Design of the Research Project Conception. These are situated within three wider perceptual boundaries: The Individual, The Enterprise and Society. 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 researchers' 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. 14.4a.

1 Introduction

> *… there are so many different real worlds out there - our real world is different to somebody else's. (14.4a)*

Cooperation and communication presume a certain level of understanding and agreed common ground. However, typically our own perceptions seem to be the most valid. Even appeals to a quantifiable 'real world' depend on agreement on what that 'real world' really is.

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.

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.

The trigger questions put to IT professionals were very similar to those put to IT researchers in an earlier part of the study:

1. Can you tell me about any IT research and development that you are interested in or involved in? Why is that research important to you?
2. What kinds of research would you consider to be most valuable for your organization?
3. In general terms (not just for your situation), do you see the projects described in these abstracts as being 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 decide whether specific projects are significant and valuable?
5. What kinds of research projects are considered as significant and valuable by industry?

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 integrating 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 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) *External horizon* represents the outer limits, or 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 own professional interests and responsibilities. In this way of seeing, therefore, the individual (here the IT professional) 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 classified in terms of those which interest the participant as a professional and those which return to the participant some professional gain.

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 which helps them fulfil their professional responsibilities or because their career is advanced in some way through it.

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.

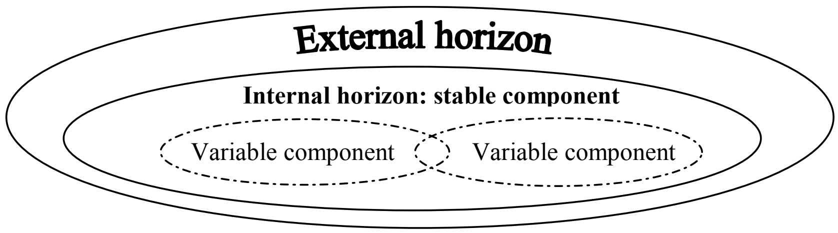

Figure 1 : Key to components of the awareness structure for each category

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 in 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.

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 1994c; 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 he 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 industry 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. Their profiles are displayed in Table 1.

Table 1 : Profiles - Industry Participants

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

Key to abbreviations
Sub-discipline: CS = Computer science, IS = Information Systems, DC = Data Communications, IM = Information Management. 'Other' sub-disciplines were described as: "Politics/history" and "Business systems".
Research experience: St = Student, Ear = Early, Exp = Experienced, NA = Not Applicable. 'Other' research experiences were described as: "Management of applied research group", "Market analysis" and "Software development".

The seven participants in this project brought with them a diverse range of perspectives, interests and experience. Four of the participants were male and three female. Most were in the thirty to fifty year old age group: one was under thirty years old, three were aged between thirty and forty, two were aged forty to fifty and one was over fifty years old. There was a broad representation of sub-disciplines: one from Computer Science, one from Information Systems, two from Data Communications and three did not consider themselves as working within the traditional IT sub-disciplines - two of these three indicated that they came from Politics/History and Business Systems backgrounds. The participants had a breadth of research experience: one considered themselves as being early in their career as a researcher, one indicated that they were an experienced researcher, two didn't consider themselves researchers at all and three considered their research experience to not fall into the normal research career guidelines – these participants described their experience as "management of an applied research group", "market analysis" and "software development".

The participants were interested in a variety of IT-related activities, through their work. These included: information management, literacy and education; software assessment, training and testing; emerging technologies; information delivery through portal and extranet technology; internet solutions for businesses; and software engineering. The application environment for these ranged from an emphasis on small businesses through to the large organization.

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 professionals' 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 contribute positively to the personal goals of the IT professional. The external horizon is the individual. The internal horizon (focus) is personal goals.
2. Category 2: The Commercial Goals Conception
   In this category significant and valuable IT research projects are seen as those which contribute to the effective running of the enterprise. The external horizon is the enterprise. The internal horizon (focus) is commercial goals.
3. Category 3: The Outcomes for the Technology End User Conception
   In this category significant and valuable IT research projects are seen as those which return a benefit to the technology end user. The external horizon is society. The internal horizon (focus) is outcomes for the technology end user.
4. Category 4: The Solving Real-World Problems Conception
   In this category significant and valuable IT research projects are seen as those which solve problems relevant to the world outside the organization. The external horizon is society. The internal horizon (focus) is solving real-world problems.
5. Category 5: 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 society. The internal horizon (focus) is the design of the research project.

In some categories the participants share the same perceptual boundary (external horizon). For example, Category 3 'Outcomes for the Client' and Category 4 'Solving Real-World Problems' share the same perceptual boundary, namely 'Society'. The widening of the perceptual boundaries assists in locating each category within an outcome space. We argue that 'Society' is a wider perceptual boundary than 'The Enterprise' and 'The Enterprise' 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 contribute positively to the personal goals of the IT professional.

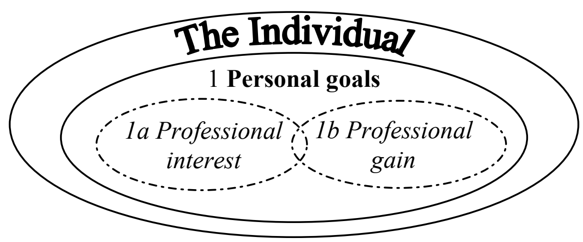

Figure 2 : Awareness structure for the Personal Goals Conception

The chief concerns of IT professional researchers in this category are personal. They are fundamentally interested in the value or impact of the research project on themselves and/or their professional role. They are not concerned with the needs of the enterprise or the world at large, nor are they considering the clients of the enterprise. Within this category varying approaches to personal goals give rise to two subcategories.

The awareness structure of this category is depicted in Figure 2. In this category, IT professionals are not seeing beyond their individual 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 fixed and variable components. 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 attract the individual's attention because they deal with a subject which is of interest to them. This interest may be generated from the possibility of improving on past professional practice within the context of the individual's own work. This contrasts with Subcategory 1b in that the emphasis here is on how personally fulfilling this experience is rather than how much it helps the individual fulfil their work goals.

> *I try to have fun. (14.7c)*
>
> *… for obscure reasons this one actually interests me in the theoretical … just one of those interest things. (14.4b)*
>
> *Some of the problems are interesting, I can sort of see some satisfaction in that, or it's satisfaction in being able to solve the problem – or … that I can actually do the work in a professional manner and do it better than I did it before. (18.1d)*

In ***Subcategory 1b*** significant and valuable research projects are seen as those which contribute positively to the individual's professional life. These projects are those which help the individual IT professional fulfil their work responsibilities by enabling the individual to work more effectively or by providing tools which can be used in the course of the individual's daily work. The research may help the IT professional solve problems related to their work, however this contrasts with Category 4 in that the focus here is on problems encountered in the individual's own work rather than problems encountered by others. This research may also help the individual meet their career goals.

> *… that gives me the proof I need to go to … [a client] … and they've been saying 'Why?' – now I'll be able to give them the 'Why'. (12.1d)*
>
> *… how I decide … is can I see how this is relevant to my work, or might be relevant to my work in the future … (15.5a)*
>
> *… if I tend to get to these sorts of papers, more often than not it's because I have a particular [professional] problem to solve and I'm looking to see how others have tackled a particular problem. So, I guess the sorts of things I am looking for are things along the lines of … Is this particular paper related to the problem I am trying to solve? (16.8d)*

Sometimes professional goals are driven by pragmatic needs:

> *I suppose the main reason they're [research and development in the workplace] important to me is 'cos it's a job and it pays the bills. Some of the problems are interesting … But apart from that some of the work I'm doing at the moment isn't overly exciting to me. (18.1d)*

5.2 Category 2: The Commercial Goals Conception

Significant and valuable IT research projects are seen as those which contribute to the effective running of the enterprise.

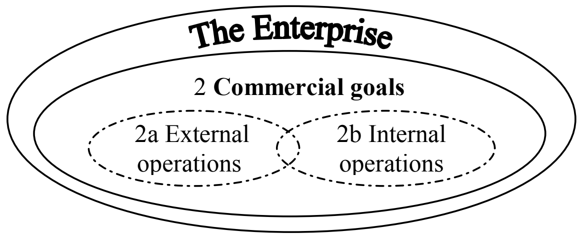

Figure 3 : Awareness structure for the Commercial Goals Conception

IT professionals' ways of seeing significance and value in this category are centred on the goals of the corporation within which they are operating. The commercial benefit returned to the corporation is their main focus. There is no apparent consideration of the professional's individual needs or for the needs of technology end users. Where end users are noted, it is with respect to the impact back on the enterprise, for example returning a commercial benefit as a result of the services rendered. Therefore, the end users are of interest only in so far as they are the organisation's clients and are thus linked intimately with the organisation's commercial goals.

The awareness structure for this category is depicted in Figure 3. In this category IT professionals are seeing solely from the point of view of the corporation itself. The enterprise, therefore, is the perceptual boundary and is indicated here as the external horizon of the category.

The stable component of the focus of this category is 'commercial goals' which has the varying orientations of 'external operations' and 'internal operations'.

In ***Subcategory 2a*** significant and valuable research projects are seen as those which enable the enterprise to function successfully in the commercial context. These projects enhance the enterprise's operations in relation to the rest of the world, they look outward to the enterprise's market. Significant and valuable research enables the enterprise to survive financially and improves on past performance, with a view to making greater profits in the future. Development is seen as crucial, an improvement in the product is viewed as gaining an advantage over the opposition. Worthwhile technical advances are those which are marketable.

> *… research that's going to be relevant to small IT companies … in terms of improving their productivity, profitability, efficiency … ability to meet their customers' needs. So it's very … commercial driven … And that's … the assessment we run across all the projects we get involved with the universities – Does it meet that need? Is it going to produce an outcome that can quantifiably help our client group? (13.3c)*

> *… each company has its own drivers and its own particular technical interests, depending on what their market is … (13.7a)*

> *I think it is important because … this firm works with information and knowledge – that's all it does, it's only experts - and it's creating documents, re-using documents … sharing knowledge, that's all we do and that's all we have to sell or to differentiate us from anyone else - so, really innovative, smart, efficient … use of that and the ability to tailor it very specifically for individual's needs, and to … for example, when we're tendering for work to make our … our ability to offer services quite different from other firms' ability because we're on top of technology before they are, is really important to us – it makes a lot of difference in how much money we earn, basically. (15.2a)*

> *… I'd certainly like to see a lot more effort in our students having a better understanding of … some of those core processes and thinking practices in industry. It's the bottom line, if you like, that drives thinking. (17.5c)*

In ***Subcategory 2b*** significant and valuable research projects are seen as those which enable the enterprise to function efficiently. These projects contribute to the internal operations of the enterprise. They facilitate the cost-effective running of the enterprise and improve on past practice. The research focuses on issues that are central concerns to the organization. The research may also solve immediate and known problems associated with the enterprise's internal operations.

> *… it saves in terms of time and dollars, so yes I think that that's … an important research area in a commercial sense. (13.6a)*

> *… looking inwards in how we can make more efficient use of systems and information within the firm so that we save ourselves time and effort and duplication and that kind of stuff. (15.2d)*

> *The goal is to try to … maximise the way that we can do things, to get best value out of the technology that is there, in practical senses. (14.1d)*

> *… there's been a fair bit of debate in Australia recently as to whether we're a first world economy or a third world economy or whether we're computerised enough or not computerised enough. To some extent this is a good example of looking at a primary industry in mining, and using technology and IT in particular as a value-add in order to improve the efficiency of that particular operation. (16.1d)*

Interrelation of the viewpoints

Category 2b, as well as Category 2a, generally impacts directly on the profitability of the corporation:

> *… they can better apply information systems management within their own organisation to improve productivity. (13.6c)*

The timeliness of research is important in this category, as it is in Category 4b:

> *I have these immediate problems and they've got to be solved, and if it's 5 years out, well that's somebody else's problem. (14.7c)*

> *I think the sorts of projects that industry are probably most interested in are those which are solving real problems that they have right now. I think, you know, industry is very selfish about this, they're certainly very much interested in how you solve my problem now - much more so than they are about what's a grander vision that we need to be moving towards in 10 years. (16.10d)*

Immediate returns are sought after, with speculative or theoretical research avoided:

> *… in the IT industry, a lot of it is just, "Well here's a problem, we'll solve that and we'll worry … yeah, that's nice emerging technology but unless it is really close to what we're doing, somebody can try and play with it in their own time" … (14.8a)*

> *… a thing is significant if you can see how it will change what you do, or how you work or whatever, and … if you are thinking about people investing money in research, they will invest money in research that they think is going to have an immediate impact on them, not necessarily so quickly invest in something that seems a bit more theoretical or abstract or … a bit more of a background issue, even if it is actually something that's quite essential for progress … (15.4c)*

The most desirable circumstance in Categories 1 and 2 is when something is of interest to the individual and at the same time of value to the enterprise:

> *Well, there are two parts. There's "Are they of importance to the company?", or "Are they of interest of me?", and then there's that happy medium when they're of interest to me and important to the company … (14.6d)*

5.3 Category 3: The Outcomes for the Technology End User Conception

Significant and valuable IT research projects are seen as those which return a benefit to the technology end user.

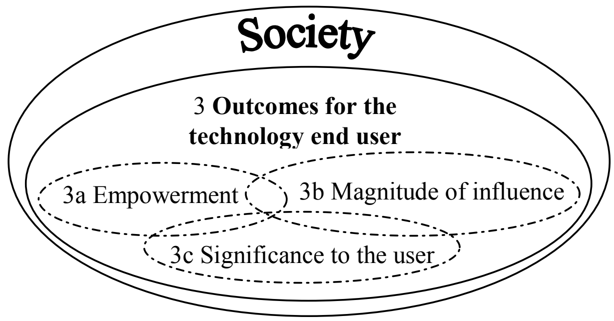

Figure 4 : Awareness structure for the Outcomes for the Technology End User Conception

The focus for IT professionals in this category is the technology end user. They are looking at research outcomes from the point of view of the benefit they return to the end user, regardless of whether there is any associated benefit to themselves or the IT enterprise.

The awareness structure for this category is depicted in Figure 4. This category takes the broadest possible viewpoint, looking beyond personal or organisational interests, therefore society forms their perceptual boundary and is represented here as the external horizon of the category.

The stable component of the category is ‘outcomes for the technology end user’, with the varying orientations of ‘empowerment’, ‘magnitude of influence’ and ‘significance to the user’.

In ***Subcategory 3a*** significant and valuable IT research projects are seen as those which act as enablers for the end user. These projects empower the end user in some way, enabling them to achieve personal goals or do their job more effectively. Through these projects IT professionals exert a constructive influence on the world.

> *IT is a service industry to the rest of the economy and the rest of the community. It needs to add some value in a lot of ways … (16.4d)*
>
> *I think the social implications for IT is a very important aspect of things. (16.5c)*
>
> *… there's a number of reasons for improving those, some of which are external things so that we can deliver more value to customers. (16.7d)*

Interrelation of the viewpoints

One participant contrasted this category with Category 2a (External operations), indicating the importance of socially responsible IT practice:

> *So, I think a lot of IT, because of the huge amounts of money that are actually involved inside our industry – so many of the wealthiest people in the world these days come from IT, so it's very possible for people to get rich very quickly. As a result of that, I think that things other than the overall community's best interest are actually driving a lot of the things that happen and that's a bit sad, but it's also like a reality – I don't know what you do about that, other than convince the people that lead these companies that in fact they should have a social responsibility and not just do things for the sake of it but look toward the bigger picture of trying to help rather than just dominate the world. (16.6c)*

In ***Subcategory 3b*** significant and valuable IT research projects are seen as those which have a large impact on the world. This impact may be in terms of how large a positive change the project produces, how many people it touches, how many applications a resulting product is relevant to or how many countries it operates in.

> *… that seems to be like a quantum improvement, which is always good … (13.5a)*
>
> *I'm one of these people who … will take a lot of that just on a gut feel, that, without formally going down and measuring – this is the size of the problem, you just know it's a big problem … (14.7a)*
>
> *This one … is pretty useful. I mean, it's the sort of thing which is discussed a lot in software engineering. (18.3b)*

In ***Subcategory 3c*** significant and valuable IT research projects are seen as those which contribute to particular groups of people. Even when the number of people it touches is not great, if the consequences for that small group are significant then the research is considered to be significant.

> *… there are key markets that will really be up on that … it would be very key for them … For some people it would be extremely significant. (14.4d)*
>
> *… that's key I think to anybody who's doing large scale system development … (14.5c)*
>
> *I suppose this has a lot of applications in computer robotics and vision and stuff like that which would be very useful in maybe … manufacturing – automatic manufacturing. (18.3a) …*

5.4 Category 4: The Solving Real-World Problems Conception

Significant and valuable IT research projects are seen as those which solve problems relevant to the world outside the organization.

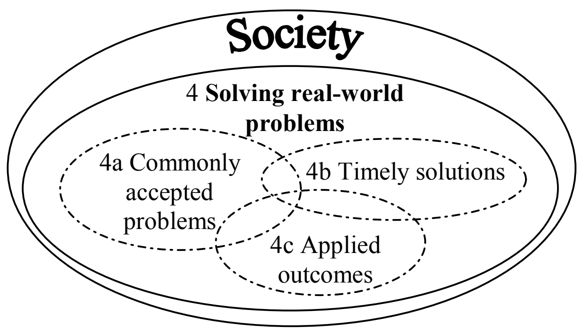

Figure 5 : Awareness structure for the Solving Real-World Problems Conception

The central focus of IT professionals in this category is the solving of problems. They are concerned with the relation of the project to society. They are not thinking of their own goals or those of the enterprise. Varying approaches within this category indicate three subcategories.

The awareness structure of this category is depicted in Figure 5. In this category IT professionals are looking beyond their own interests and the interests of the enterprise out to society, which forms their perceptual boundary and is represented here as the external horizon of the category.

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

In ***Subcategory 4a*** significant and valuable research projects are seen as those which solve problems which are experienced by a section of society. These projects are those which find solutions to problems that are commonly experienced in a subsection of the community.

> *… it certainly is good technology … it does solve a problem. (16.5d)*
>
> *… I'm not in this particular area so I can't comment from … how applicable it is and how much of a problem it is that the research is explicitly solving … (16.6d)*

> *… this is … very useful things in my opinion. This is one of the problems that I think most IT companies have constantly solved. (16.7a)*

> *… it had to meet a very significant business problem … (17.3b)*

In ***Subcategory 4b*** significant and valuable research projects are seen as those which provide solutions at the right time. These projects find timely solutions, which are applicable in the immediate future. The research follows trends of interest, anticipates future needs and is completed before the problem it's addressing ceases to be a problem.

> *… that's the trend over the last few years and probably in 5 years time there'll be something else that they think is valuable … knowledge management is just the big all-consuming thing at the moment … (15.6b)*

> *… by ... visionary research I'm talking about the sorts of things that people are looking towards what they know is going to happen because of some big changes that they're seeing that are happening in industry but that's not to say that those changes have actually been implemented yet. (16.9d)*

Interrelation of the viewpoints

Application (Category 4c) is also associated with the concept of timeliness:

> *… the third thing I'm looking for is: Is the solution and the things they're talking about something that is a bit more visionary or is it in fact something that can be delivered pretty soon or, you know, if it's an older paper that might have been written in the last 10, 20 years whether in fact it's – even if it was written visionary say 20 years ago – is it now something that can be implemented? (16.9a)*

The difficulty this presents for through-going research (Subcategory 5a) is recognised:

> *… for most IT companies in Australia that I know about, the things that they're interested in is probably the short-term research about solving real world problems now. And that's a really difficult thing for a lot of research organisations to tackle, partly because it can take that long just to get your head around what the actual problem is and where people are coming from – in which case, you know it tends to have disappeared … (16.11c)*

In ***Subcategory 4c*** significant and valuable research projects are seen as those which produce outcomes that can be implemented in the real world. These projects are seen as those which result in an application in a real-world context.

> *This one … is again I think of substantial value as long as there is, at the end of the day, some link to a real world problem … the research would need to be flipped into some real solutions relatively quickly, at least in people's minds … (17.6a)*

> *… I'd be looking for the applied benefits … (17.7d)*

> *… I suppose the way I'm valuing these is I'm probably looking at the more direct applications … (18.3b)*

> *… that was the first one I read and looked at, and thought, "Well, what's the point of this one?" (18.4b)*

Interrelation of the viewpoints

The idea of marketability of the research outcome (Category 2a) appears to have some impact on this category:

> *[Companies are] saying, "How do we cut our costs on producing software?" because, at the end of the day, their business is not about developing software, it's about marketing it. And it's the same for the manager of an IS department – at the end of the day, his job is to produce a business system rather than to develop a solution. (17.7a)*

5.5 Category 5: The Design of the Research Project Conception

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

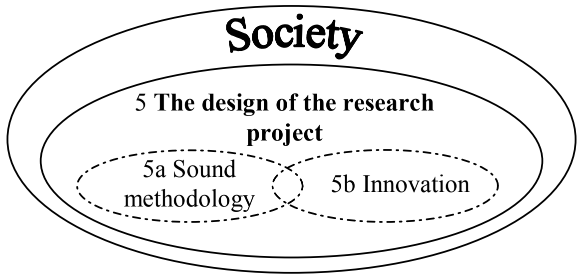

Figure 6 : Awareness structure for the Research Project Conception

The chief concerns of the IT professionals in this category are to do with the rigour of the research. They are interested in the validity of the research as research. Within this category varying approaches to the research project give rise to two subcategories.

The awareness structure of this category is depicted in Figure 6. In this category IT professionals are not concerned with their own goals nor are they considering the goals of the enterprise. Their vision is broader than both of these, therefore for the present analysis society forms the perceptual boundary and is represented here as the external horizon of the category. However, it should be noted that the exact location of this conception within the outcome space is unclear from the available data.

The stable component here is ‘the design of the research project’ and the varying orientations are ‘sound methodology’ and ‘innovation’.

In ***Subcategory 5a*** significant and valuable IT research projects are seen as those which have been designed correctly. They are conducted by researchers with an appropriate track record and who are supported by others in the field. These projects have a clear direction and clearly defined goals. The projects stand up to scrutiny from the point of view of their research standards.

> *Do the people who have written the paper communicate an understanding of what I perceive the real problem to be as opposed to what the … problem may seem to be, so I guess I’m looking for a depth of understanding of that particular field … (16.9a)*

> *… we’ve got to approach it from being … process is rigorous, and there’s a quality … it’s important that your process is followed closely and it’s seen to be globally, if you like, thorough-going … (17.8a)*

> *… I can look at the qualifications of the people on the front there … where they’re from … the fact that they’ve got in an IEEE magazine mustn’t be so bad. (12.4b)*

> *I probably look for an aim of it, so that it’s not just research for its own sake but it’s research that … they have figured out why they want to do it … it has a clear concept of what they want to find out and why … (15.5c)*

Interrelation of the viewpoints

One individual considered the presence of a model as being an inescapable aspect of significant research:

> *And how ‘rugged’ if you like, is that … model. I suppose, particularly in the venture capital industry, we talk about what’s your … business model. So I’d like to see it in that framework. What is the end result of this going to be? In a world that is in fact very tough - I mean information technology, information systems is really, really tough - and the people who survive at the end of the day, in terms of software companies, like we are, are the ones that can scratch and bite and be very focussed on what it is they want to do … I guess some of the research here for example, the research related to GIS mapping – that’s not quite the right word, but still - would seem to me that I could fit that into a business model. (17.7c)*

Another researcher saw significant research as breaking away from the commercial imperatives normally operating in industry:

> *I think this is probably a good example of a lot of things that I think are actually really good about research that gets done - taking it to that next level of actually looking at the mathematics of things and … getting in and analysing it at a level of depth that you very rarely see inside the industry. Industry tends to be driven, for better or worse, through a 'how quick can we do it', 'how much money can we make out of it' … 'is it the right cost-benefit' type thing rather than … we very rarely get a chance to actually step back and turn around and say, 'Ok well let's look at this from whoa to go and actually look at what it all means.' (16.4c)*

In ***Subcategory 5b*** significant and valuable IT research projects are seen as those which address or introduce new ideas or methods. These research projects are seen as those which explore new possibilities. They are not limited by tradition but investigate new frontiers in response to actual need. These projects tackle difficult problems creatively.

> *… to think a little bit broader. I've done some consulting around town to people on IT strategy and it's … often been very dominated by, "Oh, we've got the legacy systems, we've got to stick with them" rather than saying, "Well, if we had a blank sheet of paper, how would we deal with this and how would we in fact put a system together?" And then coming back and saying, "Well, how much will a legacy system work within that context?" So, it's about thinking isn't it, at the end of the day? It's about getting people to think … out of the box before coming back into the box. (17.8c)*

> *… getting the value out of just the data, is an incredibly difficult problem. I imagine this is trying to solve some of that really complex aspect … (14.3b)*

Interrelation of the viewpoints

The commercial motivation for innovation was seen as central by one participant:

> *I think it is important because … this firm works with information and knowledge – that's all it does, it's only experts - and it's creating documents, re-using documents … sharing knowledge, that's all we do and that's all we have to sell or to differentiate us from anyone else - so, really innovative, smart, efficient … use of that and the ability to tailor it very specifically for individual's needs, and to … for example, when we're tendering for work to make our … our ability to offer services quite different from other firms' ability because we're on top of technology before they are, is really important to us – it makes a lot of difference in how much money we earn, basically. (15.2a)*

Highly speculative innovation, therefore, may present too great a risk to the enterprise (Category 2):

> *The goal is to try to … maximise the way that we can do things, to get best value out of the technology that is there, in practical senses. Presumably there are benefits in doing the technologies, I want to find out what those benefits are … and secondly … we find it easier … to attract people if we're relatively up-to-date with the technology. We try to avoid the highly speculative. We take it not right on the {bleeding} edge, but a step back from that where it looks like it could fly, so how can we make it fly … or say that it's just not quite ready yet. (14.2a)*

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 industry 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 enterprise	2 Commercial goals (5.2)	2a External operations
		2b Internal operations
Society	3 Outcomes for the technology end user (5.3)	3a Empowerment
		3b Magnitude of influence
		3c Significance to the user
	4 Solving real-world problems (5.4)	4a Commonly accepted problems
		4b Timely solutions
		4c Applied outcomes
	5 The design of the research project (5.5)	5a Sound methodology
		5b Innovation

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 and 3/4/5. The triangle is used to depict the outer boundary, to portray clearly the three categories discussed earlier.

The outcome space constitutes an experiential framework for thinking about the significance and value of IT research projects amongst industry professionals.

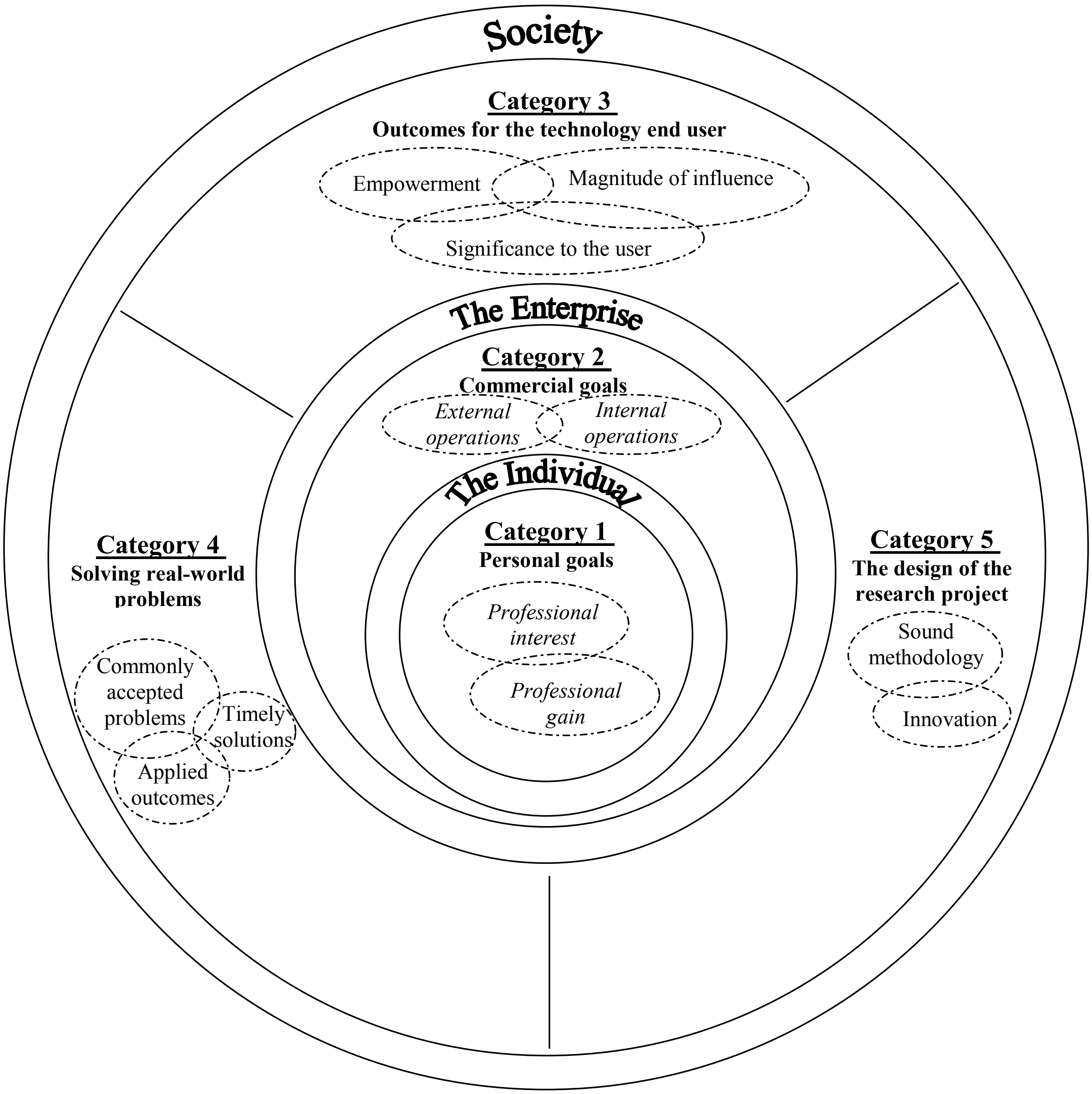

Figure 7 : Graphical representation of outcome space

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 industry professionals.

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 researchers, 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 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.

> *... information systems are really critical and research into those areas are really valid, or ... needed by industry because it's grist to the mill ... no matter what organisation you're in these days, information is key and anything that can improve that obviously has a commercial benefit. (13.5d)*

It is not clear if, in the industry view of IT research, advancement of knowledge is sufficiently covered under Subcategory 5b 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 industry researchers' ways of seeing IT research.

7.3 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 industry IT research.

> *... well I think that it should be [significant]. It depends on how the organisations want to treat their people versus just getting the job done. Increasingly, there's this social flux of saying "We're not just numbers, the organisation is the people" ... so how do you best get value out of your people and get things to work is a core part. So a lot depends on the organisational culture*

as to whether they'd be concerned about it or not. (Long pause) I think I probably should be concerned about it, to be honest. (14.3d)

… firms are much more focused these days … on how their people cope with the changes they impose on them … and there's lots of people that I can think of who would be interested in that, both in this firm and outside … people are focussing on the happiness of the worker more than they used to … (15.3a)

… they should have a social responsibility and not just do things for the sake of it but look toward the bigger picture of trying to help rather than just dominate the world. (16.6c)

I think the social implications for IT is a very important aspect of things. (16.5c)

This could be seen to be a concept which permeates all categories, or it may fall within an additional subcategory under Category 3 Outcomes for the Technology End User. Further research is needed to explore this aspect of industry researchers' ways of seeing IT research.

7.4 Comparison of industry/researcher views

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

Table 3 : Comparison of industry/researcher 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.

7.5 Industry emphasis compared with researcher emphasis

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

Within the industry participant group not all categories of description were referred to with equal frequency. The emphasis given to different categories by IT industry professionals, 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.

The category of 'Commercial 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'.

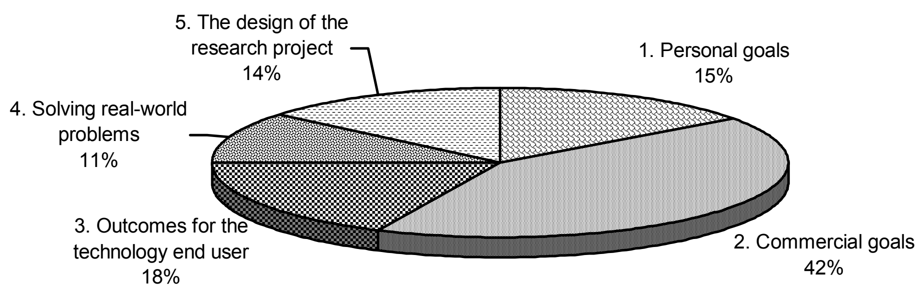

Figure 8 : Industry participant category emphasis

The emphasis given to different categories by IT researchers, as indicated by the data collected in this project, is depicted graphically in Figure 9.

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.

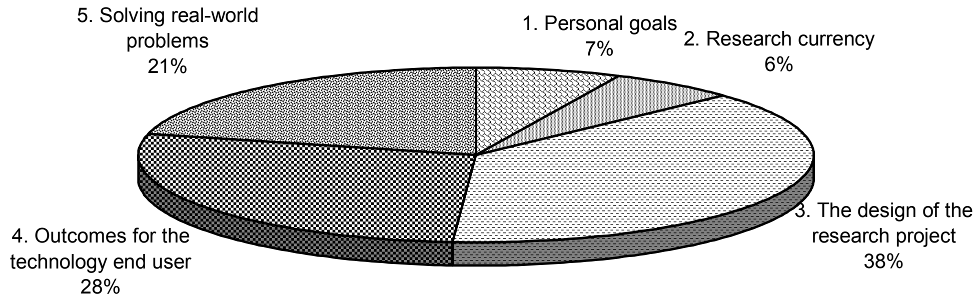

Figure 9 : Researcher participant category emphasis

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 design of 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 ‘Commercial 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 this is 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.

7.6 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.

8 References

AVCC. (1996). *Exploiting Information Technology in Higher Education: An Issue Paper.* Retrieved from http://www.avcc.edu.au/avcc/pubs/eitihe.htm

Bowden, J. (1995). Phenomenographic research: some methodological issues. *Nordisk Pedagogik 15* (3), 144-155.

Bowden, J. & Marton, F. (1998). *The University of Learning: Beyond quality and competence in higher education.* London: Kogan Page.

Bruce, C. S. (1994). Reflections on the experience of the Phenomenographic interview. In Roy Ballantyne and Christine Bruce (Eds), *Phenomenography, Philosophy and Practice,* 47-56. Brisbane: Centre for Applied Environmental and Social Education Research, QUT.

Bruce, K. (1996). Thoughts on Computer Science Education. *ACM Computing Surveys 28* (4). Retrieved from http://www.acm.org/surveys/1996/Formatting/

Gerber, R. (1993). A sense of quality – qualitative research approaches for geographical education. In H. Jager (Ed.), *Liber Amicorum Prof Niemz*, Frankfurt am Main: Goethe University Press.

Lincoln, Y.S. and Guba, E.G. (1985). *Naturalistic Inquiry.* Beverly Hills: Sage.

Marton, F. (1994). Phenomenography. In T. Husén & T. N. Postlethwaite (Eds.), *The International Encyclopedia of Education*. (2nd ed.), vol. 8, 4424 - 4429. Pergamon. Retrieved 22 May 2001, from http://www.ped.gu.se/biorn/phgraph/civil/main/1res.appr.html

Marton, F. and Booth S. (1997). *Learning and Awareness.* London: Lawrence Erlbaum

Pham, B. (1997). The Changing Curriculum of Computing and Information Technology. In *Proceedings of the Second Australasian Conference On Computer Science Education*, July 1997 Melbourne, 149-154.

Phenomenography – Terminology. (1996). Retrieved 22 May 2001, from http://www.ped.gu.se/biorn/phgraph/civil/main/firstidea.html

Roche, E.M. (1996). Multinational corporations- the merging research agenda (information technology). In *The Journal of Strategic Information Systems 5* (2), 129-148.

Sahay, S. (1997). Implementation of information technology: a time-space perspective. In *Organization Studies 18* (2), 229-261.

Saljo, R. (1988). Learning in educational settings: methods of enquiry. In *Improving Learning: New Perspectives*, Paul Ramsden (Ed.). London: Kogan Page.

Sandberg, J. (1995a). How do we justify knowledge produced by interpretative approaches? In *EFI Research Report*, Stockholm School of Economics, The Economic Research Institute.

Sandberg, J. (1995b). Are phenomenographic results reliable? In *Nordisk Pedagogik 15* (3), 156-164.

Sandberg, J. (1994). *Human Competence at Work.* Goteborg: Bas.

Simon, H.A. (1999). Information Technology Research. In *Science* 285 (5435), 1849.

Williams R, and Edge, D. (1996). The social shaping of technology. In *Research Policy 25* (6), 865 – 900.

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 I
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

1999 Third International Conference on Knowledge-Based Intelligent Information Engineering Systems, 31st Aug-1st Sept 1999, Adelaide, Australia

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 MatRISC 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,

$$\mathcal{S}_1 \subset \mathcal{S}_2 \subset \ldots \mathcal{S}_k \subset \ldots$$

where the structure $\mathcal{S}_k$ 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,

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

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

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.

---

[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-

*This research was supported by the Defense Advanced Research Projects Agency and the National Science Foundation under grant IRI-8902728.

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,