ISSN 1744-1986

The Open University

Technical Report N° 2006/08

Capturing Change Descriptions as Patterns in an Organisation's Changing Socio-Technical System

John Brier
Lucia Rapanotti
Jon G Hall

17th November 2006

Department of Computing
Faculty of Mathematics and Computing
The Open University
Walton Hall,
Milton Keynes
MK7 6AA
United Kingdom

http://computing.open.ac.uk

Capturing Change Descriptions as Patterns in an Organisation's Changing Socio-Technical System

John Brier
Centre for Research in Computing
The Open University, Walton Hall
Milton Keynes, MK7 6AA, UK
+ 44 1908 655453
J.Brier@open.ac.uk

Lucia Rapanotti
Centre for Research in Computing
The Open University, Walton Hall
Milton Keynes, MK7 6AA, UK
+ 44 1908 654125
L.Rapanotti@open.ac.k

Jon G. Hall
Centre for Research in Computing
The Open University, Walton Hall
Milton Keynes, MK7 6AA, UK
+ 44 1908 654125
J.G.Hall@open.ac.uk

Abstract

In organisations, competitive advantage is increasingly reliant on the alignment of socio-technical systems with business processes. These are complex and volatile due to the rapid pace of marketplace change. An organisation's success increasingly relies on its adaptability. Within this changing environment our work aims at developing tools that encourage an employee driven continuous process improvement opportunity, when considering the deployment and use of computing. Our focus is the analysis and synthesis of change, captured as a codification of recurrent patterns of change in a suggested notation of Change Frame Diagram. In this paper we extend our work by reinforcing with description, the change context modelled between 'before' and 'after' change scenarios, and their comparison. We identify context specific variables that support reasoning about the context in which change takes place. We exemplify our approach on a more complex real-world example than previously, resulting in a further, potential, Change Frame Diagram.

1. Introduction

The term 'socio-technical system' indicates the complex interrelationships of people and technology which includes hardware, software, data, physical surroundings, people, procedures, laws and regulations [32]. Socio-technical systems are increasingly at the heart of organisations, supporting their main business processes. This has created for the software community in general, and for the requirements engineering community in particular, a new focus for research and development. Approaches that explicitly integrate requirements analysis with the needs of organisations have started to appear in the requirements engineering literature [50, 33, 49, 2, 7].

These approaches have focused primarily on new system development. The issue of how socio-technical systems adapt to changing requirements in their organisational context remains less well understood, even though this form of change is typical. An organisation's continuing competitive advantage can often depend on the response of its business processes [17] to environmental change and the consequent re-alignment of its socio-technical systems. The drivers for change [24, 42] are typically in the environment of the organisation and can take many forms. For instance, the adoption of new business models may change expectations of what services or products should be provided to customers or expected from partners in a business supply chain. Business Process Reengineering (BPR) [17] suggests that, to respond to change, an organisation needs to understand its business processes, how to modify them, the consequences for their installed IT systems and the constraints such systems impose upon change. Grant [9] argues further that BPR should also consider other important aspects of organisations such as organisational structure, people and communication. We argue that at least as important as these, is the consideration that must be given to the organisation's business environment, precisely because that is where the drivers for change reside and where the effects of change can be best measured. This view is not dissimilar from the requirements engineering view that requirements are in the environment of a software system, and it is in such an environment that the

effects of the introduction of a system are measured. This view is of course embedded in Problem Frames [21, 22] and their conceptual basis [12].

The context for our work is the achievement of competitive advantage by an organisation, through its deployment and use of computing, and the alignment of its socio-technical systems to its business-processes and environmental conditions. Within this changing environment we aim to develop tools that encourage an employee driven continuous process improvement opportunity, when considering the deployment and use of computing. Our particular focus is the re-alignment of such systems in the face of change.

This paper represents an extension of our long term effort described at [3,4]. Here we introduced the notion of Change Frame Diagram as a pattern that represents the analysis and synthesis of changes which impact on an organisation, in the identification and codification of recurrent change scenarios, and in the application of codified wisdom to new change problems. The approach included a process of change analysis from a current to a changed business situation and their comparison. It also supported a process of synthesis through the codification of recurrent patterns of organizational change, and their application in the face of new drivers for change. We introduced the notion of Change Frame Diagram to capture this codification.

In this paper we extend our work by reinforcing the change context modelled between the 'before' and 'after' change scenarios and their comparison. We identify variables that support reasoning about this change context, and its descriptions, exampling this in a real world study that results in a potential additional, Change Frame Diagram.

The paper is structured as follows. Section 2 reviews some related work. Section 3 introduces our approach to organisational change extended to provide change context descriptions for reasoning about forces for change when change is being implemented. Section 4 applies the approach to a real-world example. Section 5 exemplifies the abstraction of a Change Frame Diagram. Finally, Section 6 includes some reflection on the approach and concludes the paper.

2. Related Work

The issue of changing systems in the face of changing requirements remains a topical issue in Requirements Engineering. The focus so far, however, has been primarily on software systems.

The literature on requirements traceability (e.g., [23] is concerned primarily with techniques for relating requirements to software artefacts and keeping tracks of changes throughout the software life cycle. [11] looks at the relation between changing business goals and the evolution of software architecture. [6] provides a classification of software requirements change, [34] a technique to classify software requirements change, while [36], as well as defining classes of requirement changes, also prioritises them according to the potential impact on the software. Change is also considered in the Viewpoints approach [35], which expresses consistency relationships between 'viewpoints' (parts or chunks) of a software specification so that the automated support for propagation of change becomes possible. Agile Software Processes (for instance, [18] are claimed able to deal smoothly with changing requirements. The presence of an on-site customer means that a conversation may be had between problem and solution owners, the low latency having a beneficial effect in recognising and communicating change.

There are two main aspects which separate our work from these approaches. The first is the consideration of social components of a system beside its technology. The second is the emphasis on an explicit representation of the context of a socio-technical system. As already mentioned, we are reinforcing our work at [3.4] by extending the notation by capturing the descriptions of the context in which change takes place. We aim to provide intelligence on the 'why' as well as the 'what' in grounding the change being implemented in its specific organisational context. This is informed by the work at [29, 30, 31] in our modelling of the notion of framework with the mapping of critical variables, but more about this later.

3. Problem Frames for Change

Problem Frames are a concretization of the ideas of Michael Jackson and others in the separation of machine and its environment's descriptions [5, 12]. This separation is generally accepted as being a useful principle for requirements analysis. The usual representation of the separation of machine and environment descriptions is as the 'two ellipse' model, illustrated in Figure 1. In that figure world knowledge *W* is a description of the relevant environment; *R* is the statement of requirements; *S* is the specification that mediates between environment and machine; *M* is the description of the machine; and *P* is the program that, on machine *M*, implements the specification *S*. The concretization of this separation in Problem Frames notation is given in Figure 2.

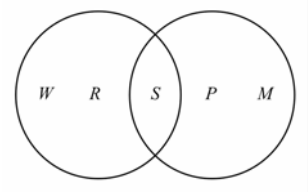


Figure 1: The Requirements Analysis Model

Figure 2: Problem Frames Concretization of the Requirements Analysis Model

In [13], Hall and Rapanotti proposed an extension to the framework to allow the design of human instruction. Foundationally, this means the separation of the description of the world from that of the human that is the subject of the design.

The concretization of this extended model in the Problem Frames is the introduction of a new domain type, the *knowledge domain*, to represent the human for which the instruction *K* has to be designed. This is represented in the general socio-technical problem diagram at Figure 3.

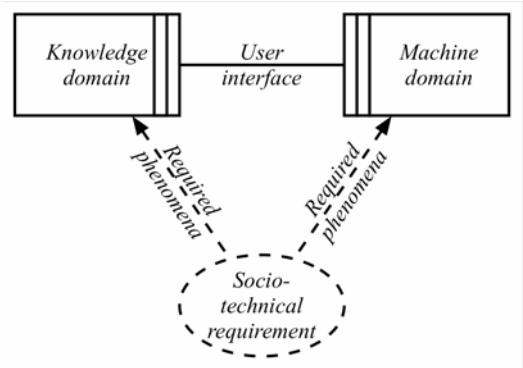


Figure 3: The General 'Socio-Technical Problem' Diagram

In the following section we introduce the notation, derived from that of Problem Frames that we have adopted and applied in our treatment of change at [4]

Problem Frames are about analyzing and solving software problems. In a Problem Frames development, it is typical to begin problem analysis with the description of the problem context – the domains in the real world that form the context of the solution which is being sought, together with the description of the requirement (the changes to the problem context the solution is supposed to bring about). In change analysis, however, rather than seeking a new solution to a problem, we need to gain an understanding of the context of the required change and identify those parts of an existing situation that are affected by the change. Therefore, the process of change analysis is not one of building a solution, but that of adapting a current situation to the change [9, 16].

To be able to support such a process, we are required to consider both before- and after-the-change situations and how the latter is arrived at from the former. We do so by taking a problem-oriented approach inspired by the separation of concerns embodied in Problem Frames. This is reflected in the notation we adopt, depicted in Figure 4.

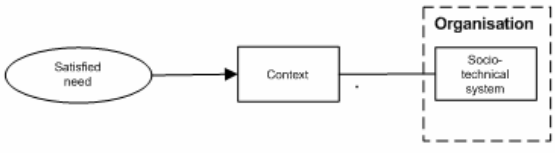


Figure 4. The Change Diagram.

As in Problem Frames, we distinguish three main component parts: the organisation, the context in which it operates, and the need the organisation supports in its context of operation and which is a focus for change. As in the 'Problem Frames' notation, rectangles represent physical domains. We also adopt the notation for phenomena, their sharing and their control (for simplicity, this last element is omitted in Figure 4). However, there are differences:

- The organisation, taking the place of the solution, is bounded by a dashed line and is modelled through a representation of its constituent domains.
- The satisfied need, taking the place of the requirement, is represented by a solid oval.

This notation will be used to give diagrammatic representation of both the before- and after-the-change situations. An important observation to be made is that all descriptions related to such diagrams are indicative: they state how things are, not how they should be. This is a reflection of the different nature of the process of change analysis as compared to problem solving.

We also give a new interpretation to the notion of adequacy (or correctness) argument. In Problem Frames, this is used to demonstrate that a proposed solution specification, in the given context, satisfies the requirement. In our context it is used as a form of

validation that current business processes support the identified need in the given context.

As well as in tools for change analysis, we are interested in a process of synthesis: given a current situation and the forces of change that exist in an organisation's environment. We aim at developing tools which offer some guidance, based on past wisdom, of how change should be effected. In other words, we aim to define Change Frames for synthesizing recurrent change situations, akin to the way basic Problem Frames [22] capture classes of recurrent software problems and their solution. In the resulting synthesis process, the progression from the before to the after-the-change situation is facilitated by the application of an appropriate Change Frame.

The development of Change Frames, similar to other patterns development [1], is predicated on the ability of comparing related pairs of before- and after-the-change diagrams, and abstracting classes of change from recurrent observations. The notation we adopt for synthesis is depicted in Figure 6. Here we have identified three simple categories of change (change of behaviour, addition and removal), which can be used to locate and classify a change that has occurred when comparing pairs of before- and after-the-change diagrams. We have also introduced a change description (dashed oval): this is an optative statement of what the change is supposed to achieve. In our previous work [4] we also introduced a change description (dashed oval) which was related to other parts of the diagram through descriptions of a driver and lever for change.

This papers aim develops further, the change context being modelled, in grounding the descriptions in their specific organisational context. This includes descriptions of the 'why' as well as the 'what' of the change context being considered. We reinforce with descriptions the change context modelled between 'before' and 'after' change scenarios, and their comparison. In identifying critical variables that support reasoning about these descriptions the following has been considered from the literature. Pettigrew and Whipp [38] with their five central factors model introduced the notion of *framework* for capturing change in organisations. This is supported by Martin and Meyerson [29] with their *framework* of three perspectives. McWhinneys work [31] suggests an understanding of change through *mapping various realities*. This is taken further by McCaskey [30] who applies it to *realities that are important*. In considering what kind of framework would be most effective for mapping and describing change situations, assessing the *environment* is seen as a first step [24] with the external and internal assessments being integrated in a system that links both *strategic* and *operational* activities of the organisation. The three contexts of *environment, strategic and operational* can contain different forces for change [24, 39] For example, environmental forces can stimulate a change response at the strategic level of an organisation, which can then be transformed into a change response at the operational level of the organisation. We have therefore described the different contexts containing the forces for change as *environmental, strategic and operational.* This is further detailed by adding to the driver and lever change descriptions at [4] the notion of enablers and foundations as at [43]. This more detailed capture and description reflects the need in organisational change to achieve a congruence of identified variables [44, 46]. This also contributes to the provision of a structured framework that captures the more fine grain detailed descriptions of the change context being modelled. [43, 49]

Depending on the change context being described we consider that the drivers, enablers, levers, foundations (DELF) framework can be considered at the three levels of *environmental,* and/or *organisational strategic* and/or *organisational operational*. They are described as follows [20, 43]:-

Driver - the force through which the change is initiated.

Enabler - represents the development of knowledge and sharing covering structure, culture and environment.

Lever - the action through which the change is realised. Covering processes, tacit and explicit knowledge, measures, hubs and centres and market leverage.

Foundation - a combination of hard and soft infrastructure tools and techniques, that determine the ultimate capacity and capability of an entity to deploy change. Hard infrastructure equates to the information communication technology infrastructure and soft infrastructure relates to the human and organisational structures, systems and policies.

The DELP is identified on the change diagram by arrows. The driver arrow identifies where the driver comes from. The enabler, lever and foundation arrows identify where they reside in the context where change is being implemented. In Figure 5 the direction of the arrows are for illustration purposes only.

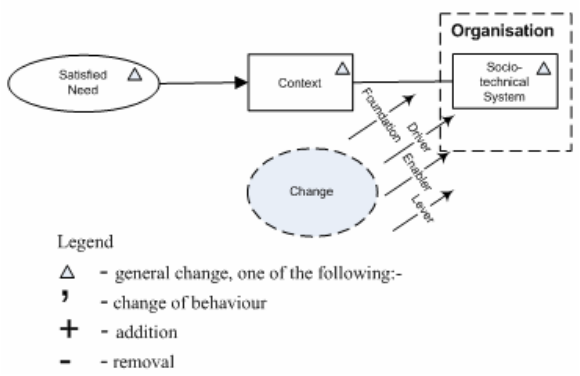


Figure 5. Notation for Change Synthesis.

In the next section we perform a change analysis by applying the tools and notation described in this section, on a more complex real world example than previously [4]

4. Change analysis - A Real World Example

The example, taken from [28], is representative of a real-world situation, that of Infosys (India) and their program towards becoming a knowledge sharing organisation. It represents a more complex real-world example than previously exampled [4] for reasoning about the context in which change takes place. Also, this real world context examples the relating of an existing situation, to a strategic plan for change (as apposed to a change that already existed as in previous work). This provides a different context for the analysis of our tools and the tracking and traceability of change in an organisations socio-technical system.

In 1999 Infosys launched an organisation wide formal knowledge management initiative having decided that:
'*…all the knowledge sharing mechanisms that existed until then needed to be synergized under a common umbrella, with a clearly articulated vision and strategy for implementation…*'[28]

In the case study Infosys Technologies Ltd is described as an IT consulting and software services organisation headquartered in Bangalore India. Founded in 1981, the company had grown at a compounded rate of 70% over the last decade. Structurally the company was significantly Bangalore-centric and it operated globally, with eight development centres in India, five in North America, and one in each in the UK, East Asia and Australia. In this study these are referred to as Infosys Global Development Offices (IGDO). There were marketing offices in about a dozen other countries. Infosys accepted that knowledge was a key competitive differentiator and, given the knowledge intensive nature of Infosys business, a clear understanding of its knowledge capital had always been considered essential.

The before-the-change situation represents the situation at Infosys before the change initiative. Prior to 1999, Infosys had believed that the effective utilization of its knowledge base would be pivotal to success. In response to this it had made available some knowledge based IT on its intranet. For example, the part of the system referred to as the Body of Knowledge (BOK) which was an organisation wide repository that made available to its employees, experiential learning gained through the execution of software projects.

The after-the-change situation represents the Infosys design to implement a knowledge management architecture. This required a more comprehensive deployment of knowledge management technologies, that would align the technologies used, and the organisation's business processes, with the culture of the organisation. This was to be accomplished by an adoption of an organisation wide knowledge management initiative, in the belief that the:
'*…. knowledge sharing mechanisms that had existed before, now needed to be synergized under a common umbrella……where every action was fully enabled by the power of knowledge…*' [28]
The following analysis of the change was made with reference to the case study only. The authors have had no part in the work done in developing the case study, and have only reverse engineered the change as described in [28]. To the best of our knowledge, problem frames were not used in producing any of the Infosys developments as described in the case study.

4.1. Before The Change

The before the change situation is captured in Figure 6. In the figure, the context is represented by two domains; the Infosys Global Development Offices (IGDO), and the Client. There are both electronic (a 'fledgling' intranet) and non-electronic communication links that provide for the exchange of information between the IGDO's and the structurally centric company headquarters at Bangalore. The required need selected for the purpose of representing the techniques in this study, is that of the provision by Infosys of information and knowledge to its IGDO's.

Structurally the company is Bangalore centric, which is the location of its Headquarters where the

Chairman, CEO, COO, and other fulltime members of the board are based. The dashed line represents the scope and boundary of all the non-electronic and electronic domain activities relevant to this real world study and are represented as follows:-

Infosys Operations - the operations domain includes the organisation's major functions of Finance, Planning, Marketing, Quality, Human Resources etc. that receive both electronic and non-electronic requests for information.

Intranet (Sparsh 1997) – a central information portal, installed in 1997 and providing access to a Home page, the BOK, the Virtual Classroom, Email and the People Knowledge Map.

Knowledge Management IT - the domain representing the knowledge management technologies in Infosys in the 'before the change situation'. These included the Body of Knowledge with an intellectual property rights template, the Virtual Classroom with a discussion forum, Email with a technical bulletin forum and the People Knowledge Map, with a knowledge hierarchy.

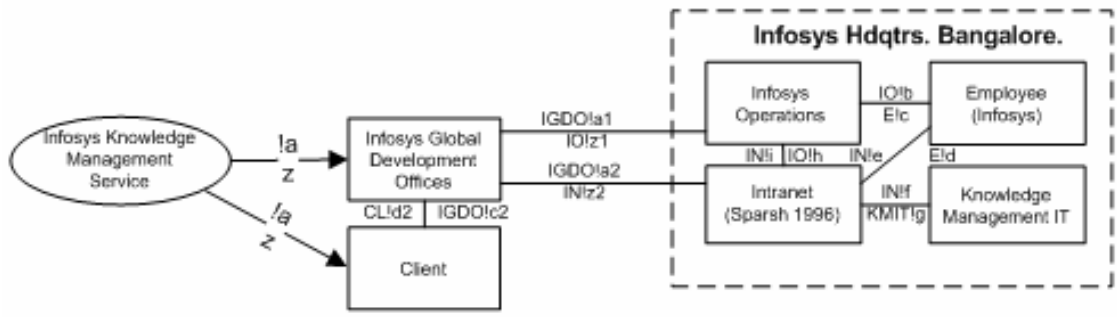
Employee (Infosys) which represents all staff interfacing with IT.

The context is represented by the following domains:-

Infosys Global Development Offices (IGDO) represents the global network of Infosys offices and their need to obtain information from Infosys.

Client - represents the domain of interest for clients intent on obtaining information from Infosys. Figure 6 includes details of all sets of shared phenomena of interest based on the notation used in problem frames [22]. The three component parts of the socio-technical problem are related through shared phenomena descriptions, e.g. events, states or commands, which are represented as links between the domains and the required need.

For example, in the figure, the Infosys Global Development Offices require a service (phenomena in a) from Infosys Operations. This is captured by the notation as IGDO!a1 . In being shared, the phenomena are visible to both domains. The provision of that service is represented by the phenomena description IO!z1. In the figure the arrow expresses the fact that the 'required need', constrains the phenomena in the set *!a*. If the arrow was replaced by a straight line it would mean that the '*required need'* only referred to the phenomena.



The table in the figure provides descriptions for the phenomena at each of the domain interfaces.

!a	*require service*		e.g.	*The provision by Infosys of a knowledge management service.*
a1	*require non-electronic service*		e.g.	*A Global Development Office request for non-electronic information*
a2	*require electronic service*		e.g.	*A Global Development Office request for electronic information*
b	*alert employee*		e.g.	*Infosys Operations alert the employee (Infosys)*
c	*non-electronic information*		e.g.	*The Employee (Infosys) provides non-electronic information to Infosys Operations*
d	*forward request*		e.g.	*The employee (Infosys) accesses the Intranet*
e	*electronic information*		e.g.	*The Intranet(Sparsh 1996) provides information for the Employee (Infosys)*
f	*forward request*		e.g.	*The Intranet (Sparsh 1996) provides access to the Knowledge Management IT*
g	*electronic information*		e.g.	*Knowledge Management IT provides information to the Intranet*
h	*forward request*		e.g.	*Infosys Operations request access the Intranet*
i	*electronic information*		e.g.	*The Intranet(Sparsh1996) provides information to Infosys Operations*
z	*provide service*		e.g.	*Infosys Headquarters provide service to Infosys Global Development Office and Clients*

z1	*provide non-electronic service*		e.g.	*Infosys Operations provide non-electronic information to the Infosys Global Development Offices*
z2	*provide electronic service*		e.g.	*Infosys Global Development Office obtain electronic information from the Intranet(Sparsh 1996)*
d2	*make request*		e.g.	*The Client makes a request to the Global Development Office*
c2	*provide information*		e.g.	*The Global Development Office provides information to the Client*

Figure 6. Before The Change Diagram

The need which is currently satisfied by Infosys is in its provision of knowledge management information for the Infosys Global Development Offices as illustrated in the following examples:-

'… when Infosys Global Development Offices require an electronic service (a2), access to electronic Knowledge Management IT (f) provides knowledge information (g) providing the service required (z2)…'

"….when Infosys Global Development Offices require a non-electronic service (a1) access for non-electronic information (b) provides non-electronic information (c) providing the service required (z1).."

"…..when a client, requires a service (a) they make a non-computer contact with the Infosys Global Development Office (d2) that provides the information (c2), providing the service required (z)…"

As problem frames were not used in the original development, explicit justification for the correctness of the before-the-change diagram and its descriptions cannot be provided.

4.2. After The Change

Figure 7 represents the Infosys *strategy* to implement a company wide knowledge management architecture represented by the Knowledge Portal and its access to the Centralised and Decentralised Knowledge Management (KM) Functions. The Infosys Global Development Offices electronic access to the Intranet (WEB) now provides access to an integrated body of organisational knowledge. Clients have Internet access to the company Intranet (WEB) through a Virtual Private Network (VPN). The new Knowledge portal and its access to the Centralized and Decentralized Functions signifies potential company wide social and technical changes in the knowledge role played by the employees. Change could impact on this employee domain, for example, in the need to adapt to changing processes and/or the need for training. The Infosys Headquarters have now deployed a computer- based architecture for knowledge management that aligns the specific business context to the cultural context of the organisation. The domains, with their changed characteristics, are described as follows:-

Infosys Operations - which includes the organisation's major functions of Finance, Planning, Marketing, Quality, Human Resources etc. now has Intranet (WEB) access to Infosys Global Development Offices, Clients, and a Knowledge Management Portal.

Intranet (WEB) - linked to the Knowledge Management Portal developed to include web based technologies, extensively networked to the Infosys Global Development Offices via dedicated communications to its Clients using the Virtual Private Network.

Employee (Infosys) now have access to the Intranet (WEB) and its comprehensive provision of context specific communications and knowledge.

Virtual Private Network (VPN) links connect the company's network to those of clients.

Centralised and Decentralized Knowledge Management Functions – the location of functional expertise of well defined central components within a decentralized technological architecture. The considerations to be addressed are described in the case study as Content Architecture, Technology Architecture, People Architecture and Process Architecture.

Knowledge Management Portal – providing access to the Centralised and Decentralised Functions.

The context is represented by the following domains:-

Infosys Global Development Offices (IGDO) are now extensively networked through dedicated electronic communications that provide access to clients along with access to the Knowledge Management Portal.

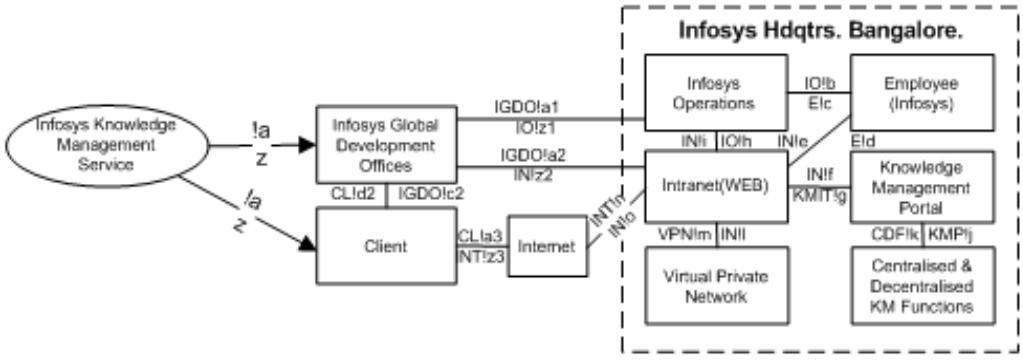
Client – represents the domain of interest for clients who now have context specific access to the Infosys network.

The Internet – providing the context by which clients can access the Virtual Private Network.

As before, there is a non-computer communication link maintained that facilitates the exchange of information between Clients, the Infosys Global Development Offices and Infosys Operations. Figure 7 represents the 'after the change' diagram. There are consequent changes to the shared phenomena. (see table in Figure 7), examples of which are described as follows:-

'… when Infosys Global Development Offices require a service (a2), they access the Knowledge Management Portal (f) to access the Centralized Functions & Decentralized Functions (j) Knowledge management information is provided (k) satisfying the service required (z2)…'

'…..when a Client, requires a service using the Internet (a3) they access the Virtual Private Network (l) to obtain context specific information (m) providing the service required (z3)…'



The table in the figure provides descriptions for the phenomena at each of the domain interfaces.

!a	*require service*	e.g.	*The provision by Infosys of a knowledge management service*
a1	*require non-electronic service*	e.g.	*Infosys Global Development Office request for non-electronic information*
a2	*require electronic service*	e.g.	*Infosys Global Development Office request for electronic information*
a3	*require electronic service*	e.g.	*A Client request for electronic information*
b	*alert employee*	e.g.	*Infosys Operations alert the employee (Infosys)*
c	*non-electronic information*	e.g.	*The Employee (Infosys) provides non-electronic information to Infosys Operations*
d	*forward request*	e.g.	*The employee (Infosys) accesses the Intranet(WEB)*
e	*electronic information*	e.g.	*The Intranet(WEB) provides information for the Employee (Infosys)*
f	*forward request*	e.g.	*The Intranet (WEB)provides access to the Knowledge Management Portal*
g	*electronic information*	e.g.	*Knowledge Management Portal provides information to the Intranet(WEB)*
h	*forward request*	e.g.	*Infosys Operations request access the Intranet(WEB)*
I	*electronic information*	e.g.	*The Intranet (WEB) provides information to Infosys Operations*
z	*provide service*	e.g.	*Infosys Headquarters provide service to Infosys Global Development Office and Clients*
z1	*provide non-electronic service*	e.g.	*Infosys operations provide non-electronic information to the Infosys Global Development Offices*
z2	*provide electronic service*	e.g.	*Infosys Global Development Office obtain electronic information from Intranet(WEB)*
z3	*Provide electronic service*	e.g.	*The Client obtaining context specific electronic information from the Intranet(WEB)*
d2	*make request*	e.g.	*The Client makes a request to the Infosys Global Development Office*
c2	*provide information*	e.g.	*The Infosys Global Development Office provides information to the Client*
n	*electronic request*	e.g.	*The Internet requests access to the Virtual Private Network*
o	*electronic access*	e.g.	*The Intranet(WEB) provides context specific access to the Internet*
m	*electronic request*	e.g.	*The Virtual Private Network requests context specific access to the Intranet (WEB)*
l	*electronic access*	e.g.	*The Intranet(WEB) provides context specific access to the Virtual Private Network*
j	*electronic request*	e.g.	*The Knowledge Management Portal provides access to the Centralised & Decentralized Knowledge Management Functions*
k	*transfer electronic information*	e.g.	*The Centralised & Decentralized Knowledge Management Functions transfer knowledge managed information to the Knowledge Management Portal*

Figure 7 – The Problem Diagram After The Change

In this after-the-change situation the system still satisfies the same need to provide a knowledge management service. However, the service is now improved through the provision of electronic access to company wide additional knowledge management information. IGDO's now have access to an Intranet (WEB) linking to the Knowledge Management Portal with access to Centralised and Decentralised Functions that have integrated existing IT with new IT, and provided a synchronization of the business processes with the culture of the company.

4.3. Capturing The Change

When making an analysis of the change, a representation of the before-the-change situation is first considered, in which a separation between the organisation, its context, and the satisfied need was maintained. (Figure 6). A representation of the after-the-change situation was then given, which maintained the same separation of concerns (Figure 7). Having these two representations provides an opportunity for the analysis of the impact of change, in terms of the three component parts. This is illustrated in the resulting change diagram at Figure 8.

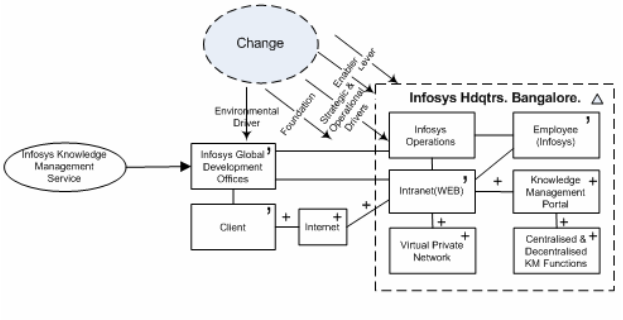


Figure 8. The Change Diagram

Figure 8 identifies that change has occurred within the socio-technical system of the Infosys Headquarters. The organisation wide knowledge management driven redesign has integrated the existing Infosys IT systems, with its new knowledge management technologies based on an alignment of its business processes with the culture of the organisation. The notation in Figure 8 shows change in existing and new domains and their interfaces. Note that by considering Infosys as the provider of a service, the employee in its socio-technical system is not considered as a mere user of IT, but as an important component in the service provision who is, as such, trained to follow certain procedures. As the socio-technical system changes in response to various drivers, both social and technical parts of the organisation may change. [13]. For example, the Intranet (WEB) domain now provides a new link between requests for information, and all the organisation's centralized and decentralized activities. Here, for example, there are potential consequent changes required in the Client domain (e.g. new procedures) and the Employee (Infosys) domain (e.g.: training)

The optative statement of change is '*…that an improvement in Infosys ability to manage its knowledge is required, in order to codify and commodify knowledge more advantageously, in its drive for competitive advantage…'*

In providing descriptions of the context in which change takes place the change diagram, description and optative statement of change are further supported by descriptions of the DELF as explained at Figure 5. There was no reference to the DELF in the case study and the descriptions included here are abstractions from the case study the authors have selected to illustrate potential DELF descriptions in practice. For the purposes of this real world study, *Drivers of change* are identified in the *Environmental Context*, the *Strategic Context* and the *Operational Context*. The *Enablers, Levers, and Foundation* descriptions are abstracted from those aspects of the case study that impact on the *Operational Context* for change, all described as follows:-

Driver - the force through which the change is initiated, identified as an environmental driver, strategic driver and operational driver.

Environmental Driver - the ascendance in the marketplace of knowledge as a key competitive differentiator.

Strategic Driver – deciding on a policy that has impacted on the organisation's approach to the four dimensions of culture, process, content and technology.

Operational Driver - the implementation of an IT architecture based on knowledge management.

Enabler – to progress knowledge development and sharing covering an organisation's structure, culture and environment.

A number of knowledge management practices existed pre-dating the company's formal knowledge management initiative. Detailed discussions were also completed with various constituencies within the organisation as part of the change management programme.

Lever - the action through which the change is realised. Covering processes, tacit and explicit knowledge, measures, hubs and centres and market leverage.

Exampled by a network of Delivery Excellence Managers charged with deploying the change processes in the software delivery units, and ensuring adherence.

Foundation - *The knowledge of the 'foundations' is generally outside the scope of the case study but located in the existing evolutionary relationship between the organisation's socio-technical systems and its business processes.*

The adequacy argument that states why the change is adequate to the need for change can be expressed as follows:

'…When Infosys Global Development Offices *require improved electronic information service*, then they *connect* to the WEB Intranet, *access* the Knowledge Management Portal, *request information* from the Centralised/ Decentralised Knowledge Management Functions *completing the improved service* to Infosys Global Development Offices, *hence satisfying the need…'*

5. Towards The Capture of Recurrent Change

By taking some inspiration from basic problem frames, the aim has been a codification of Change Frames as a tool for synthesis, which by matching a before-the-change diagram for a particular class of change, would allow it to be transformed into a corresponding after-the-change diagram. As such, Change Frames capture the broad characteristics of the organisation, the context, their interfaces, the need, and the adequacy argument that states why the change is adequate to the need for change. This includes the capture of change descriptions, and the location of the forces for change and their descriptions (DELF), both external and internal, with their potential influences on the social and technical contexts of the socio-technical system.

As for other types of patterns, methodologically, the codification of Change Frames can only be achieved through a process of abstraction of recurrent observations, illustrated here through the abstraction of a change diagram of a real-world case study.

Figure 9, based on this real world case study, exemplifies, with its focus on knowledge management and alignment, one such possible abstraction. This change frame provides a potential frame for use by a company, where organisational change impacts on the following. Non IT and IT related activities including WEB based Intranet communications, and the management of its knowledge. This is illustrated by the Clients context specific internet connection to the organisation's network (VPN) and an alignment of its business processes with its knowledge management activities. This is exampled here by the Knowledge Management Portal domain, and the Centralized and Decentralized Functions domain. Also by the DELF descriptions identifying the forces for change and the critical variables describing the context for change. These reinforce the context for reasoning about the consequence of change, and the potential for identifying patterns supporting the implementation of change. For example, when an organisation wishes to implement an Intranet WEB link to its context and a knowledge management architecture (as in this real world study) does the following abstractions of critical variables from the DELF descriptions provide a potential implementation pattern for change.

Strategic Driver - deciding on a policy that has impacted on the organisations approach to the four dimensions of culture, process, content and technology.

Enabler - A number of knowledge management practices existed pre-dating the company's formal knowledge management initiative.

Lever - Exampled by a network of Delivery Excellence Managers charged with deploying the change processes in the software delivery units, and ensuring adherence.

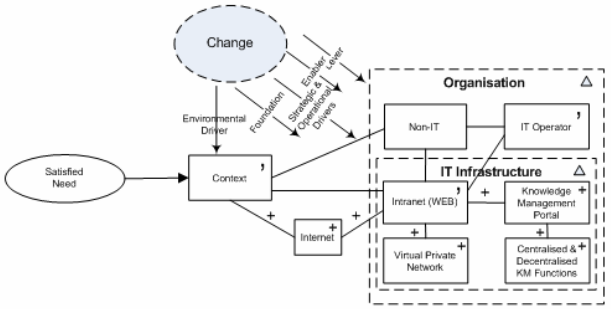


Figure 9. Towards a Change Frame

6. Discussion and Conclusion

The context for our work is the achievement of competitive advantage by an organisation through its deployment and use of computing, and the alignment of its socio-technical systems to its business-processes and environmental conditions. This work is focused on the development of tools that encourage an employee driven continuous process improvement context that, in considering the way computing is deployed and used, is perceived as a ubiquitous opportunity for change. This case study represents an extension of the work begun in [3,4], where we modelled a notation which can help in the analysis of changes which impact on an organisation, in the identification and codification of recurrent change scenarios, and in the application of codified wisdom to new change problems.

The approach has some notable characteristics. In taking its inspiration from problem frames, it allows for a separation of concerns between an organisation, its context and a satisfied need, the representation of the complex context in which organisations operate, the expression within a unified notation of both before- and after-the-

change situations, and a corresponding adequacy argument. Also, by allowing the representation of socio-technical systems, hence the separation of social and technical parts of an organisation, it makes it possible to reason about changes which go beyond technology. This is crucial if organisational change is to be properly represented.

The approach includes a process of change analysis and corresponding notation, from a current to a changed business situation and their comparison. The intent is to provide intellectual tools for reasoning about the improvements brought about by the change. The approach also aims at supporting a process of synthesis through the codification of recurrent patterns of organisational change, and their application in the face of new drivers for change. The notation of Frame Diagram is proposed for the capture of such patterns.

In this paper, we have extended previous work exemplified in a more comprehensive exercising of tools on a more complex real-world example from the literature; reasoned about the context in which change takes place through the introduction of the DELF descriptions; and introduced a potential Change Frame Diagram. Compared to our work at [4], we have successfully tested our process for capturing change on a more complex real-world example. In this case a context for change that required descriptions when implementing an Intranet (WEB) link to the context in which the organisation operates, in tandem with a knowledge management architecture. This also exampled the relating of an existing situation to a strategic plan for change (as apposed to a change that already existed as in previous work). When thinking of the design, tracking and traceability of change, in an organisation's socio-technical system this informs the context in which our tools can be applied. We have reinforced potential change frame descriptions by introducing DELF. The DELF provides the opportunity to describe the 'why' as well as the 'what' in providing context specific detailed descriptions in supporting an understanding and tracking of the implications of change. The DELF descriptions link, in implementation terms, the 'before and after' change situations. They provide, with their identification of context specific critical variables and their description, a modelling opportunity of the context in which change takes place. Here the identification of drivers separates three sources of the forces for change (environment, strategic, operational) informed by the notion of enablers, levers and foundations. Descriptions here will codify the relationship between the forces of change being considered and the competences and capabilities of the organisation that are being used to harness them. In completing the analysis and synthesis of change the DELF descriptions will inform the implementation of change as follows; on the impact of implementation on the social components as well as the technology; on the potential for more fine grain pattern description in the implementation context being considered; on the process of synthesis by identifying and codifying recurrent implementation patterns in the context where change takes place; and, in the design of change frames when considering their supporting descriptions. The detailed descriptions of DELF will also support the further modelling of a notation understandable by developer/designers and employees, in providing an effective context for organisations to reason about their deployment and use of computing. This will include, when considering the implementation of change, modelling the traceability and tracking characteristics, when change takes place over time.

Developing work will focus on change impact analysis, the development of the concept of Change Frame, and the identification and validation of a significant number of patterns for organisational change. The contexts to be considered include change that occurs through the redesign of human activity when deploying and extending computer activity, the alignment of socio-technical systems in organisations, and the alignment of an organisation's socio-technical systems and culture, with their business process and business model activity .

7. Acknowledgements

We are pleased to acknowledge the financial support of IBM, under the Eclipse Innovation Grants, and the EPSRC, Grant number EP/C007719/1. Thanks also go to our colleagues in the Centre for Research in Computing in The Open University, particularly Michael Jackson, Bashar Nuseibeh and Zhi Li.

8. References

[1] C. Alexander, A. Ishikawa, M. Silverstein, M. Jacobson, I. Fiksdahl-King, S. Angel. A Pattern Language, Oxford University Press, 1977.

[2] S. Bleistein, K. Cox, and J. Verner. Problem frames approach for e-business systems. In K. Cox, J. Hall, and L. Rapanotti (eds.), 1st International Workshop on Advances and Applications of Problem Frames, pages 7–15, Edinburgh, IEE Press 2004.

[3] J. Brier, L. Rapanotti, J. Hall. Towards capturing Change in Socio-Technical Systems Requirements. In Proceedings of the 11th International Workshop on Requirements Engineering - Foundation for Software Quality, pages 225-237, 2005.

[4] J. Brier, L. Rapanotti, J. Hall, Problem-based Analysis of Organisational Change – a Real-world Example, in proceedings of IWAAP at IEEE 28th International Conference on Software Engineering.

[5] P. Bresciani and P. Donzelli. A practical agent based requirements engineering framework: the conceptual modelling for novel application domains. Lecture notes in Computer Science, Vol. 2814/2003, pages 217–228, 2003.

[6] J. Buckley, T. Mens, M. Zenger, A. Rashid, and G. Kniesel. Towards a taxonomy of software change. Journal of Software Maintenance and Evolution: Research and Practice, 2002.

[7] K. Cox, K. Phalp, S. Bleistein, and J. Verner. Deriving requirements from process models via the Problem Frames approach. Information and Software Technology, 2004.

[8] B. Dervin. Chaos Order and Sense making; A proposed theory for information design. In R. Jacoson (ed.) Information design, Boston Mass., MIT Press, 1999.

[9] H. M. Franken and W. Janssen. Get a grip on changing business processes results from the test bed project. Knowledge and Process Management, 5(4):208-215, 1998.

[10] D. Grant. A wider view of business process re-engineering. Communications of the ACM, 45(2):85–86, 2002.

[11] D. Gross and E. Yu. Evolving system architecture to meet changing business goals: an agent and goal-oriented approach. In Proceedings of the Fifth International Symposium on Requirements Engineering (RE01), 2001.

[12] C. A. Gunter, E. L. Gunter, M. Jackson, and P. Zave. A reference model for requirements and specifications. IEEE Software, 17(3):37–43, 2000.

[13] J. G. Hall and L. Rapanotti. Problem Frames for Socio-Technical Systems. In J. Mate and A. Silva (eds.), Requirements Engineering for Socio-Technical Systems, Idea Group, Inc., 2004

[14] J. Hammond, R. Rawlings, and A. Hall. Will it work? In Proceedings of the 5th IEEE International Symposium on Requirements Engineering, 2001.

[15] S. Harker, K. Eason, and J. Dobson. The change and evolution of requirements as a challenge to the practice of software engineering, In Proceedings of IEEE International Symposium Requirements Engineering, San Diego, CA, USA, 1993.

[16] P. Haumer, P. Heymans, M. Jarke and K. Pohl. Bridging the gap between past and future in RE: a scenario-based approach. In Proceedings of IEEE International Symposium on Requirements Engineering, pages 66–73, 1999.

[17] P. Henderson. Software processes are business processes too. In Proceedings of the Third International Conference on the Software Process, pages 181–182, 1994.

[18] A. Highsmith, J. Cockburn. Agile software development: the business of innovation. Computer, 34(9):120–127, 2001.

[19] V. Hlupic and S. Robinson. Business process modelling and analysis using discrete event simulation. In WSC ’98: Proceedings of the 30th conference on Winter simulation, pages 1363–1370, Los Alamitos, CA, USA, IEEE Computer Society Press, 1998.

[20] Interim Australia Standard (2003) AS 5037, Standard Australia.

[21] M. A. Jackson. Software Requirements and Specifications. Addison Wesley, 1995.

[22] M. A. Jackson. Problem Frames: Analyzing and Structuring Software Development Problem. Addison-Wesley Publishing Company, 1st edition, 2001.

[23] M. Jarke. Requirements tracing. Communication of ACM, 41(12):32–36, 1998.

[24] G. Johnson & K Scholes. Exploring Corporate Strategy-Text and Cases, Prentice Hall (1989)

[25] C. Jones. Variations in software development practices. IEEE Software, 20(6):22–27, 2003.

[26] R. Kaplan, D. Norton. The Balanced Scorecard. Harvard Business School Press, 1996.

[27] T. Katayama, T. Tamai, and N. Yonezaki. Principles of software evolution. In Proceedings of the International ISPSE 2000 Japan. IEEE inc., 2000.

[28] V. P Kochikar and J.K. Suresh, ‘Towards a Knowledge Sharing Organisation: Some Challenges Faced on the Infosys Journey in Annals *of Cases on Information Technology 2004, Volume 6, edited by M. Khosrow-Pour*. Idea Group inc., 2004.

[29] J. Martin, D. Meyerson, (1990) Organisational Cultures and the Denial, Channelling and Acknowledgement of Ambiguity in Pondby, L.R., Boland, Jr, R.J., Thomas, H. *Managing Ambiguity and Change;* John Wiley & Sons Ltd----47

[30] M. B. McCaskey (1990) The Challenge of Managing Ambiguity and Change, in Pondby, L.R., Boland, Jr, R.J.,

Thomas, H. *Managing Ambiguity and Change;* John Wiley & Sons Ltd…..48

[31] W. McWhinney, (1992) *Paths of Change: Strategic Choices for Organisations and Society:* Sage Publications, London.

[32] J. L. Mate and A. Silva, editors. Requirements Engineering for Socio-Technical Systems. Information Science Publishing, 2005.

[33] J. Mylopoulos, M. Kolp, and J. Castro. UML for agent-oriented software development: The TROPOS proposal. In Proceedings of the Fourth International Conference on the Unified Modelling Language UML 01 - Toronto, Canada, 2001.

[34] N. Nurmuliani, D. Zowghi, and S. Williams. Using card sorting technique to classify requirements change. In Proceedings of the 12th IEEE International Requirements Engineering Conference (RE'04), Kyoto, Japan, September 2004.

[35] B. Nuseibeh, S. Easterbrook, and A. Russo. Leveraging inconsistency in software development. Computer, 33(4): 24–29, 2000.

[36] J. O'Neal and D. Carver. Analyzing the impact of changing requirements. In Proceedings of the IEEE International Conference on Software Maintenance, pages 190 – 195, 2001.

[37] E. Paolucci, F. Bonci, and V. Russi. Redesigning organisations through business process re-engineering and object-orientation. In Proceedings of the European Conference on Information Systems, pages 587–601, Cork, Ireland, 1997.

[38] A. Pettigrew, R. Whipp, (1993) *Understanding the Environment*, in Managing Change, edited by Mabey, C. Mayon-White B, Open University in association with Chapman Publishing Ltd, London…57

[39] M Porter. Competitive Advantage: Creating and sustaining superior performance. Free Press, 1985.

[40] L. Prusak. The knowledge advantage. Strategy and Leadership, 24(2):6–8, 1996.

[41] S. Robertson and J. Robertson. Mastering the Requirements Process. Addison Wesley, Harlow, England, 1999.

[42] R. Stacey. Strategic Management and Organisational Dynamics. Prentice Hall, 2003.

[43] D. J. Skyrme. Knowledge Networking - Creating the Collaborative Enterprise, Oxford Butterworth-Heinemann, pp 177-211 (2002)

[44] J. D.Thompson, O*rganisations in Action,* New York, McGraw-Hill 1967

[45] K. Tumay. Business process simulation. Proceedings of the WSC'95 - Winter Simulation Conference, pages 55–60, Washington DC, USA, 1995.

[46] M. L.Tushman, D. A. Nadler, ' Information Processing as an Integrating Concept in Organisational Design' in *The Academy of Management Review,*Vol.3, No.3, (Jul.1978) pp 613-624

[47] A. van Lamsweerde. Goal-oriented requirements engineering: A guided tour. In Proceedings of the 5th IEEE International Symposium on Requirements Engineering (RE2001), pages 249–263, Toronto, 2001.

[48] K. E. Weick. Sense making in Organisations. Thousand Oaks, Calif. Sage Publications, 1995.

[49] R. Weiringa, J. Gordijn, and P. van Eck. Value framing: A prelude to software problem framing. In K. Cox, J. Hall, and L. Rapanotti (eds.), 1st International Workshop on Advances and Applications of Problem Frames, pages 75-84, Edinburgh, IEE Press 2004.

[50] E. S. Yu. Modelling organizations for information systems requirements engineering. In Proceedings 1st IEEE International Symposium on Requirements Engineering, pages 34–41, 1993.

[51] P. Zave. Classification of research efforts in requirements engineering. ACM Computing Surveys (CSUR), 29(4):315–321, 1997.

[52] Zave P. and Jackson, M., (1997) Four Dark Corners of Requirements Engineering ACM Transactions on Software Engineering and Methodology, ACM Transactions on Software Engineering and Methodology, ACM Press, Vol. 6, No. 1.