Problem-based Analysis of Organisational Change: a Real-world Example

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ABSTRACT
An organization’s competitive advantage is increasingly reliant on the alignment of its socio-technical systems with its business processes. These are complex and volatile due to the rapid pace of change in the marketplace, hence an organisation’s continued success is increasingly reliant on its ability to adapt to change. In this paper, we take a small step towards providing tools which can help in the analysis and synthesis of change which impacts on an organisation’s socio-technical systems, in the identification and codification of recurrent change scenarios, and in the application of codified wisdom to new change problems. The tools we propose are inspired by Problem Frames. We exemplify the approach on a small real-world example.

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D.2.1 [Software Engineering]: Requirements/Specifications.

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Organisational change, socio-technical systems. Problem Frames.

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 [26]. Socio-technical systems are increasingly at the heart of organizations, 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 [41, 27, 40, 3, 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 realignment of its socio-technical systems. The drivers [30] for change are typically in the environment of the organization 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 [10] 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 [20, 21] and their conceptual basis [12].

The context for our work is the achievement of competitive advantage by an organisation through the alignment of its socio-technical systems to its business-processes and environmental conditions. Our particular focus is the realignment of such systems in the face of change.

This paper represents one step in our long-term effort, started in [4], on providing tools 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.

Our approach takes some its inspiration from Problem Frames, in particular in its emphasis on the separation of a system from its context. The diagrammatic notation we adopt is also adapted from that of Problem Frames. The approach includes a process of change analysis from a current to a changed business situation and their comparison. It also aims at supporting a process of synthesis through the codification of recurrent patterns of organizational change, and their application in the face of new drivers for change. The notation of Change Frames is proposed for the capture of such patterns.
The paper is structured as follows. Section 2 reviews some related work. Section 3 introduces our approach to organizational change. Section 4 applies the approach to a real-world example. Section 5 exemplifies the abstraction of a Change Frame. 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., [22]) is concerned primarily with techniques for relating requirements to software artifacts 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, [28] a technique to classify software requirements change, while [31], 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 [29], 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, and as recognized elsewhere [15], although change is experienced in such systems, the source of the change has most often to do with the environment. Typically, it is the changing nature (or changing understanding) of real-world contexts, customers, suppliers, legislation, the marketplace, etc., that drives change; understanding the changing context of a system is therefore a fundamental aspect of dealing with change.

3. PROBLEM FRAMES FOR CHANGE
In the rest of the paper we assume the reader is familiar with the basics of Problem Frames [21]. In this section we introduce the notation, derived from that of Problem Frames, which we adopt in our treatment of change.

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 been 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 1.

As in Problem Frames, we distinguish three main component parts: the organization, the context in which it operates, and the need the organization 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 2). However, there are differences:

- the organization, 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 a driver for change (more about this later), 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 [19] 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 2. 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. The change description is related to other parts of the diagram through driver and lever [30] arrows. A driver is what identifies that the current situation is not adequate and needs to be changed; the driver arrow identifies where the driver comes from. A lever represents the mechanism by which the change is realized; the lever arrow identifies where the lever resides.

![Change Diagram](image)

**Figure 2. Notation for change synthesis.**

In the next section we perform a change analysis on a real world example, by applying the tools and notation described in this section.

## 4. CHANGE ANALYSIS: A REAL-WORLD EXAMPLE

The example, taken from [2], is small, but representative of a real-world situation, that of the City of Tampere (Finland) and their program towards citizen-centred local e-government. The City has built up its information networks since the 1980’s; with the development of the Internet, it has recognised the potential for making information available to its citizens more readily. The example we have taken represents one change implemented by the City in the process of developing its information networks.

The before-the-change situation is one in which the City has deployed technology mainly in internal administrative processes for word processing, payroll administration and accounting. The after-the-change situation represents the City’s additional provision of a computer network to link the City’s administrative processes to external citizen services, local universities and local telephone operations. The driver for the change came from the City’s objective to build up and computerise its information networks and make them more readily accessible to its citizens.

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 [2]. To the best of our knowledge, Problem Frames were not used in producing any of the City of Tampere’s developments as described in the case study.

### 4.1 Before the change

The before-the-change situation is captured in Figure 3. In the figure, the context is represented by the External Services domain and its interfaces. This domain is an abstraction of citizen services, local universities and the local telephone operations; it encompasses all the facilities provided for its citizens by the City of Tampere; it is not electronically networked to the City’s administration domain.

The ‘organization’ is the City of Tampere itself, comprising, as parts of its socio-technical systems, the following domains:

- City Departments: this domain is an abstraction of all of the city internal departments which receive requests from External Services;
- Administration: this is further decomposed into IT (all the computerized administrative systems), IT Operator (all staff interfacing with the IT) and Archive (all non-electronic administrative systems).

Figure 3 includes details of all sets of shared phenomena of interest in Problem Frames notation. For instance, in the figure, that the External Services require a service (phenomenon in a) is captured by the notation as ES1a. The table in the figure provides descriptions for the phenomena at each of the domain interfaces.

![Before-the-change Diagram](image)

**Figure 3. Before-the-change diagram.**

The need which is currently satisfied by the City of Tampere is that of providing administrative services to the community, that is when External Services require a service (a), an appropriate service is provided (x) by the City. Note that by considering the City as the provider of a service, the IT Operator 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.

As Problem Frames were not used in the original development, we have no access to any explicit justification for the correctness of the before-the-change diagram and its descriptions. However, having reverse-engineered from the case study the essential parts of the context, the organization and
the need, we can now provide a plausible corresponding adequacy argument. As already mentioned, in this context the adequacy argument captures the business process that the organization follows in order to support the need in the given context. A possible argument, involving all given descriptions and phenomena, is:

When External Services require service, then the City Department forward request to the IT Operator, who, depending on the request, access IT or access archive, or both, in order to access electronic information and non-electronic information, then provide information to the City Departments that provide service to External Services, hence satisfying the need.

4.2 After the change

Adding the internal electronic network to the City of Tampere’s socio-technical system results in the situation depicted in Figure 4. The new domain Network appears in the organization, representing its new electronic network. External Services have direct electronic access to Network, with consequent changes to their shared phenomena. Within the City of Tampere’s Administration, the IT Operator receives requests via the network, which instigate the provision of both electronic and non-electronic information. Hence, there are consequent changes to the shared phenomena (see table in Figure 4).

4.3 Capturing the change

The analysis of the change in the example has followed the process of analysis outlined in Section 3. First of all, a representation of the before-the-change situation was considered, in which a separation between the organization, its context and the satisfied need was maintained. A representation of the after-the-change situation was then given, which maintained the same separation of concerns. Having these two representations provides an opportunity for the analysis of the impact of change in terms of the three component parts. Using the notation introduced in Section 3, the resulting change diagram is given in Figure 5.

The figure identifies where changes have occurred, each type of change and the levers and drivers for change. In particular, it can be seen that the Network domain and its interface with both External Services and IT, have been added, while a change of behaviour may occur in the IT domain (e.g., a new interface to the network) and the IT Operator domain (e.g., further training or new procedures to follow).

The optative statement of change is that an improvement in the service provision to External Services is required in order to make information more readily available. The driver for change has its origin in the organization itself (a decision from the City’s executive), where the lever (the improvement to the IT infrastructure) also resides.

5. TOWARDS THE CAPTURE OF RECURRENT CHANGE

As already mentioned, by taking some inspiration from basic Problem Frames, we aim at the 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 should capture the broad characteristics of the organization, the context, their interfaces, the need and the adequacy argument. It should also capture the change descriptions, and any lever and driver for change.

As for other types of patterns, methodologically, the codification of Change Frames can only be achieved through a process of abstraction of recurrent observations. We conjecture that this could be achieved through the abstraction of change diagrams of real-world case studies and examples.
exemplifies one such possible abstraction — that this is yet to be proved a Change Frame follows from the fact that it is derived from a single observation.

In the figure, we depict what may be consider the precursor of a Change Frame for improving networked communication within and across an organisation’s boundaries. The addition of an electronic network, as an improvement of the organisation’s IT infrastructure, will require changes both to the existing IT and IT-related personnel in the organization. It will also require changes in the interface across the organisation’s boundaries. Also, the driver for such a change may come from within the organization, which is where the lever resides.

Figure 6. Towards a Change Frame.

6. DISCUSSION AND CONCLUSION

The focus of our work is organizational change through the realignment of socio-technical systems to business processes and environmental conditions.

This paper represents one step in our long-term effort, begun in [4], on providing tools 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 corresponding adequacy arguments. 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 suitably 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. For instance, in our example, that more immediate, timely and therefore effective access to administrative information has been obtained, or that efficiency gains and cost reductions had been achieved through automation. This remains the subject of future work.

The approach also aims at supporting a process of synthesis through the codification of recurrent patterns of organizational change, and their application in the face of new drivers for change. The notation of Change Frame is proposed for the capture of such patterns.

In this paper we have taken a small step by successfully exercising our tools on a small real-world example from the literature. Compared to our initial attempt in [4], we have refined, on a new real-world example, both analysis and synthesis tools and clarified the conceptual basis of our approach and its relation to Problem Frames. We have also introduced the notion of drivers and levers from [30], which were missing from our previous effort.

Future 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 organizational change.

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8. REFERENCES


