Coordinating People And Technology Through Process.

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Abstract.

This paper contends that it is essential that Information Technology is designed to serve organisational goals, to fit comfortably within work patterns, and to enable rather than constrain change to these work patterns. To achieve this it is necessary to adopt a systemic approach to design whereby the relationship between all the components (people, work, support technologies) is understood. From this understanding there follows the opportunity to design technology systems which can do work and coordinate work between people in a fruitful way. This division between doing work and coordinating work, though crude, is a useful paradigm for revealing new roles of technology. Doing work (e.g. calculating invoice totals, providing performance figures) can be described as the established domain of IT. The coordination of work (i.e. who does what when) is a newer, evolving role for technology. Many new technologies support the coordination of work between people (e.g. process enactments, workflow). A systemic approach to design can realise the benefits of these coordination technologies and harmonise their functionality with that of more traditional IT.

Work processes are at the centre of attention of many industrialists and managers (evidenced by initiatives such as Total Quality Management and Business Process Redesign) as well as software engineers (evidenced by software process modelling). The Informatics Process Group (IPG) of the University of Manchester use the process as a framework around which the support technologies can be designed. The concept of process of encapsulates both the doing and the coordinating aspects of organisational behaviour. The IPG have carried out several case studies under full commercial conditions. Conclusions and lessons from some of these case studies are discussed. In particular it is noted that a much closer cooperation between the manager and the IT developer is being encouraged by the process perspective. The manager's focus on process enables him/ her to look for benefits such as greater efficiency, increased product direction and empowered worker roles. The process designs can in part at least, (and especially for process enactments), provide a brief for the IT developer.

Thus it is through an understanding of work processes that the relationship between technology and people can be explored. This implies a need for informative and precise process models. The IPG have, in conjunction with industrial partners, dedicated effort to developing process modelling methods and graphical notations. This has led to the development of the Process Modelling Cookbook, in collaboration with British Telecommunications plc, and the more recent Process Analysis and Design Method, (PADM) on behalf of the IOPT consortium. Some of the latest ideas are introduced.

Finally the paper makes a case for further study of the way processes change in organisations. The case studies have revealed that the vitality of organisations is expressed through their

responsiveness to changing conditions and the ability to innovate. A quick response to changing conditions may often be achieved through some degree of non-conformance to prescribed processes. Innovation may be achieved through rapidly setting up new processes to achieve new goals. This means that technologies that constrain work patterns and inhibit change can be detrimental to organisations. As change and dynamism become increasingly important to modern organisations so too computer support will be required to coordinate flexibly whilst making behaviour and evolving processes visible to team members.

Introduction: Making IT Fit The Needs Of The Organisation.

Morgan [Mor86] asserts that organisations are "complex and paradoxical," and uses competing and yet concurrent metaphors to explore their nature. Identification and examination of different metaphors is used to reveal the essential nature of organisations because "..the use of metaphor implies a *way of thinking* and *a way of seeing* that pervade how we understand our world generally." Organisations are, as Morgan says, "..many things at once!"

Yet because the organisation is inevitably the domain of IT it is essential that we appreciate its nature, though it may be complex and uncertain, as fully as possible. Failure to do so will mean that we affect features of organisations in unintended ways with consequences ranging from poor exploitation of technology to "..more conflicts and dysfunctions... with calamitous results" [Eas90]. Lyytinen's account of the failure of Information Systems (IS) notes that "..organisations rearrange their structures and streamline procedures, organisational culture and climate change, the external environment is in a constant flux etc. For these reasons the IS can become 'unfit' to stakeholders expectations" [Lyy88].The well documented failure of IT systems in general can therefore at least in part be accounted for in terms of a failure to appreciate the character of organisations whereby we find that systems do not achieve an organisational goal, suppress informal ways of working, debilitate coordination networks or become out of step with evolving practices etc.

There is no widely accepted definition of an organisation. Lucey's [Luc89] list of commonly accepted organisational features is therefore useful and shall provide some focus for the following discussion:

1. They are goal oriented and therefore contain people working with a common purpose.
2. They are social systems and contain people working in groups.
3. They are technical systems containing people using knowledge, techniques and machines.
4. They integrate structured activities. Therefore people work together and coordinate their activities.

There is enough in this list to capture some of the recognisable components of organisations. Keywords include "goal oriented," "social systems," "groups," "technical systems," "structured activities" and "people...coordinate."

The work of Mumford [MH79] incorporates the concept of 'fit' between aspects of an employee's job as it is and as they would ideally like it to be. Her proposed participative approach to computer systems design attempts to use the new technology to move the job as it is towards the job as it ideally might be. However to make IT fit the needs of the organisation as a whole we need to broaden the focus of job 'fit,' without intention to devalue it at all, and look at issues of goal orientation, "social systems," "groups," "structured activities," the use of machines and the coordination of people. We need an assessment of 'organisational fit' and to be able to view an organisation as a system containing components that have potential and motivation for interaction.

The Process Construct.

The process construct can be used for the development of knowledge about important aspects of organisations. Through it the interaction of people and groups can be explored, repetition and predictability of actions can be shown, actions can be related to one another and the func-

tions undertaken by technology can be shown in a broader human oriented context. It does not give us a complete understanding of organisations, their structure and behaviour, but is a framework to which many issues can be commonly related. Moreover, it is a particularly appropriate platform upon which to design and evolve IT systems, especially the new process oriented, coordinative technologies later described.

White defines a process as "..an ordered and *coordinated* set of activities for the attainment of a particular goal" [Whi93]. Both the degree of ordering and the extent of coordination of activities are variable between processes. Some processes are highly ordered and have strong coordinative structures. Others are less discernably ordered and may have fewer coordinative characteristics. The mapping of these activities, their ordering and coordination gives us a description of objective oriented behaviour in organisations. At the heart of the description there is always a process model. Curtis et al. write "Process modeling is distinguished from other types of modeling in computer science because many of the phenomena modeled must be enacted by a human rather than a machine.....Rather than focusing solely on the user's behavior at the interface or the flow and transformation of data within the system, process modeling also focuses on interacting behaviors among agents, regardless of whether a computer is involved in the transactions."[CKO92]

It can therefore be seen that process modelling makes an approach to the design of IT possible whereby the relationship between people, work and support technology is understood. This approach suggests that the organisational metaphor used by Morgan [Mor86] which is most closely related to process modelling is the systems metaphor. Indeed it can be shown that this process oriented approach shares common ground with the influential soft systems work of Checkland [CS90]. Systems theory identifies the world as containing structured wholes or objects. Components of the structure are potentially or actually involved in complex inter-relationships. Soft Systems Methodology applies these concepts to 'unstructured,' complex problem areas where human perceptions and relationships have a significant impact and there is unlikely to be a simple, single solution. Process modelling relies upon the concept of process for exploration and description of the relationship between parts of a work system. Thus the following quote from Checkland might equally apply to a process oriented approach as to systems thinking: "..an approach to a problem which takes a broad view, which tries to take all aspects into account, which concentrates on interactions between the different parts of the problem" [Che81]. Process modelling differs in that through the concept of process it has a prescribed framework intended for meaningful, objective oriented exploration of the work activity sub-system.

This description of the process framework as *objective oriented* merits further consideration. The definition of process given earlier relates the set of activities to "..the attainment of a particular goal." The boundaries of processes are best drawn and understood by reference to goals. The concept of a goal or objective is therefore fundamental to process modelling.

Coordination Technology.

The continuing development of computer systems has been a catalyst for the development of process modelling methodology. Computer systems are moving from being tools for well defined and limited purposes to being highly integrated parts of the overall system of the organisation. New coordination technologies can model organisational structures and procedures. They make it likely that systems will become still more pervasive within

organisations and make the need to ensure a good fit between the system and the organisation even more compelling.

Coordination technology is defined by Curtis et al. as "..an aid to managing dependencies among the agents within a business process.." which "..provides support for the most routinized component processes." [CKO92]. The distinction between 'doing work' and 'coordinating work' is a crude but useful paradigm for understanding what is meant by coordination technology. Traditionally IT has done work (e.g. calculating invoice totals, providing performance figures). New technologies have expanded this role by 'coordinating work' between people in a process. Thus a typical coordination technology might pass insurance claims between relevant clerks according to an internal process representation. For example, the system passes Clerk Y all house insurance claims to process using an editor and a spreadsheet, the claim is then forwarded by the technology to Clerk Z for approval.

The term 'coordination technology' is used here as a collective term for technologies which have this coordinative functionality but originate from research in different domains. Much workflow technology has developed from networks and open systems research. It operates through the transfer of an object, in most cases a document, between users of a system. This is usually done over an existing email network on the basis of a rule set encoded into the system. A number of impressive case studies have been recorded [Ovu92]. European software process research programmes have led to the development of two products usually labelled 'process enactments.' ProcessWEAVER [Fer93] and ProcessWise [BPR91] enact (or execute) a sophisticated process model which has explicit knowledge of participants, tools, data needs and conditions. ProcessWEAVER uses a petri-net graphical modelling capability which allows processes to be described from three perspectives; management, team interworking and team member. The ProcessWise system was originally developed as IPSE 2.5 [War90] under the Alvey Software Engineering initiative in the UK. It has its own language for description of the process to be enacted. The Process Management Language (PML) has language primitives which include roles, entities, actions and interactions. Snowdon [Sno92] points out that one benefit of such a language is that the system can be designed in terms that equate with human activity concepts in the real world process. The necessity for the IT developer to invert his or her view and consider the process in terms of simple computations is therefore much diminished.

This is one way in which a process model can be used to create a closer relationship between managers and IT developers. However if we insist, as we should, that IT is subservient to process this benefit should be available to conventional IT also.

Current Process Initiatives.

Process modelling is not new but has been developing rapidly as a result of a number of factors including changing commercial pressures, disaffection with IT, the need for quality products, and the need for flexible business practices. Particularly interesting is that different communities of interest have separately come to focus on the process. The following are foremost in the use of the process construct. Many of them have been referenced in the development of process modelling methodology designed to coordinate people and technology.

The software process has become a major research topic of the software engineering community. In the United States the work of the Software Engineering Institute has received much attention. The creation of a Process Maturity Framework [Hum88] was a response to the

Defense Department's need for some way of characterising the development capabilities of software organisations. The underlying thesis is akin to Total Quality Management (see below) in that a better developed and managed process will produce a higher quality product. The Process Maturity Framework is critically evaluated at [BM91] and [HC91].

Bank writes "The manager needs to create a corporate culture where quality products and services, business processes and people are central" [Ban92]. This summarises the focus of Total Quality Management (TQM), a major initiative aimed at ensuring that industry develops and manufactures high quality products to satisfy customer requirements. The concept of process is important in TQM because the emphasis is taken from quality testing at the end of manufacture and placed upon ensuring quality right through, from the design inception or start of manufacture through to customer delivery. Mortiboys [Mrt90] summarises this as "..a cost-effective quality management culture" based upon "controlling the process rather than controlling the people or the product."

Business Process Reengineering initiatives have received publicity in both Europe and North America. They are sometimes labelled Business Process Redesign without apparent difference in content. White describes their concern as "..going back to basics and examining what the processes are really trying to achieve" [Whi93]. Hammer's paper "Don't Automate, Obliterate!" [Ham90] points to the folly of using IT to merely automate old business practices. He emphasises the opportunity of using new technology to make new ways of working possible

The Management In The 90s programme proposes a similar agenda of innovation through the deployment of IT. Venkatraman writes "Instead of treating the existing business process structure as a constraint in the design of an optimum IT infrastructure, the business process itself is redesigned to maximally exploit the available IT capabilities. This reflects conscious efforts to create an alignment between the IT infrastructure and the business process, rather than simply superimpose the technology platform on the existing business processes" [Ven91]. This in part results from the "..truism that markets are becoming highly competitive" wherein the benefits of innovation and fast response to competitors are critical.

Process Modelling Methodology.

The Informatics Process Group (IPG) of the University of Manchester use process models to describe components such as actions, interactions, conditions and the deployment of technology in organisational processes. The work has been enriched by case studies and concern for issues posed by new coordinative technology. An important tenet underpinning the work is that in developing or evolving processes, technology must be subservient to the designed process.

The Process Modelling Cookbook [Kaw91] was developed by the IPG as part of a collaborative project with British Telecommunications plc (BT). BT are a process literate company in that they organise their business according to process structure and have designated "owners" responsible for the operation and development of processes. It was observed that [EFJK91] there were no methods available to guide the production and use of process models within the company or commercially available elsewhere. The Process Modelling Cookbook was an attempt provide such a method. It has a simple structure of Representation and Refinement through which a model is built and then analysed. The model itself is quite sophisticated being constructed through the use of process charts, data flow diagrams, object flow diagrams and role activity diagrams (RAD). These describe a process vocabulary of people, roles, actions,

interactions, conditions and objects.

Subsequently the IPG have developed the Process Analysis and Design Method (PADM) [Whi93] as part of the U.K. government funded Introduction Of Process Technology (IOPT) project. PADM is less prescriptive than the Process Modelling Cookbook, has a more sophisticated structure and advocates involvement of users in the modelling exercise to a greater degree. It will provide a complete method for process modelling activity from the capture and analysis of process through to design and support specification. It proposes a series of graphical notations for the process modeller to use. These include process charts, dependency diagrams, RADs and a new RAD based notation, the Activity Diagram (AD), which was developed through case study experience. It provides a framework of modelling activities, some of which are already well understood, whilst others demand further research. These include Baseline Process Capture, Process Evaluation, Process Development Objectives Definition, Target Process Design and Specification Of Requirements For Automated Support. A feature of PADM is that it views process modelling as itself a concurrent process. Practical experience has shown that it is naive and restrictive to assume that the modeller will be able to complete these activities in a strict sequence. It is more flexible in practice to be able to alternate between activities or iterate activities as demanded by the analysis and design process itself.

An interesting notion featured in the work of the IPG is that of the 'process engineer' who works in an organisational setting. This is someone who may, in a future dominated by intense competition, market discontinuities and pressure for innovation, be "..engaged in the design of organisational processes, capturing the dynamics of the organisation, ensuring that the human system within which the IT system is embedded is properly considered, and developing plans to change it where necessary..." [Whi93].

There remains a significant research agenda for the development of process methodology. The provision of rich and yet easily legible modelling notations remains an important topic. The use of four notations in the Process Modelling Cookbook is still among the most rich but makes modelling a fairly slow and arduous task. There are also significant consistency problems. This is one of a number of areas in process modelling where the development of suitable tools may advance the discipline significantly. Another research issue is the phenomenon of process change. This needs to be better understood and harnessed more productively.

Case Studies.

This research agenda has motivated the IPG to undertake a number of process modelling case studies in industry. One of these looked at BT's bill production process. This is a well defined, well understood process that has been subject to revision and improvement over a number of years. It works effectively and is not a problem area for BT. However as part of a manifesto of continuing improvement the company is concerned to find new ways of managing and supporting the process to make it more flexible and still more effective. For example the company may want to offer greater customer choice about the content, frequency and format of bills. This will require that the process be able to produce a more variable and sophisticated product within cost constraints.

The case study was conducted using the Process Modelling Cookbook. Information was gathered through interviews with BT staff on two sites. This information was first recorded in a structured format using the process construction chart or simply as text. Graphical models

developed initially loosely conformed to the data flow formalism. As the study progressed the data flow diagrams became better defined and use of the RAD and object flow notations started. Validation of the graphical models was carried out throughout the study by presenting them to members of the billing team. This proved to be a time consuming activity which slowed the research and could, if appropriate care had not been taken, been a rather onerous burden for BT staff. This is one reason why PADM (which was developed after the Process Modelling Cookbook) recognises that process modelling is a participative activity with users involved in model building as well as validation. It was also noted that the process modelling exercise needed support from modelling and analysis tools.

The case study confirmed the high efficacy of the billing process. It also noted that the process had been subject to substantial change which would continue for the foreseeable future. Pressures for change come from a number of sources such as general market conditions, customer requirements and technological advances. However, the case study identified an active programme of technological development as an especially significant motivation for change. Furthermore, among a list of observations made of the process were the following:

- The process is currently supported to a high degree by a conventional, sophisticated IT system. This system is difficult to change. There are examples of managers wanting to reoganise the process in some way but finding themselves constrained by the IT system. The system can be modified but this is done by a separate division of BT and due to the particular constraints and pressures of their work, can take months. This situation is typical of countless companies the world over. To a manager seeking flexibility to cope with changing circumstances, or to innovate or respond to temporary problems, the delays incurred can be significant. This is a justification for the development of process support systems which are easy to change. Snowdon discusses the existing change facilities in ProcessWise in [Sno92-2].
- Most bills are handled automatically by the IT system. The staff only handle exceptions taken out of the system for charge verification, error correction or alteration to requirements. Currently the process of handling these exceptions is largely dictated by the design of the database transactions. This is not conducive to ergonomically good working. A proposal has been made whereby the work process is redesigned and the database transactions made to serve it.

A second case study concerned a process by which the interworking capability of computer systems components was verified. This took place in a large company and was very different to the bill production case study in that it was a new process, incorporated a greater degree of managerial and technical working, and did not have clearly defined outputs. It was recognised that the IPG's brief would have to be flexible in that the study itself would have to determine whereabouts maximum benefit from process modelling could be obtained.

The case study was conducted in part using methods and techniques proposed for PADM. The principal of greater user involvement was already adopted. Interviews took place over a number of months but on several occasions staff undertook to model their own processes (using the Activity Diagram (AD) notation). Workshops were used to try and clarify objectives for the process. These made use of techniques from Soft Systems Methodology [CS90]. The IPG are currently involved in the collaborative development of a new process for revised objectives.

The improvement proposals tended to be concerned with interface issues where the process

can be seen to depend upon different organisational teams. Very often in the IPG's experience, teams can work effectively in a self contained way but without adequate interaction with the wider organisation.

A number of major lessons for process modelling methodology were learned from both the above case studies. These include the aforementioned concurrency of activities in the process modelling process and the need to involve users. Furthermore there has been a shift in thinking about process modelling. Previously it had been seen as predominately a *terminating* process, i.e. a number of stages were gone through, a result was achieved (an improved process) and then the modelling activity stopped, until it was felt necessary to go through it again. Process modelling should indeed be capable of being used in this way, but in many situations, especially those subject to rapid change, it is more valuable to see process modelling as a *continuous*, non-terminating process, similar in nature to planning and monitoring processes, and linked to them. Thus whenever appropriate in new case studies the IPG are trying to implant process modelling methods into the studied organisation. Thus they gain long term use of a process framework for exploring the coordination of people and technology in an objective oriented, organisational context.

Process Change.

The phenomenon of process change has been mentioned in passing a number of times earlier in this paper. It is one of the most significant issues for process methodology to address. Processes may change for a number of reasons. For example, there may be a formal requirement for them to do so as a result of new objectives. Alternatively they may change as a result of employees finding ways to informally rationalise their work or make it more interesting. These are examples of positive change, that is where change is perceived to be a beneficial event. There is also detrimental change. For example the degradation of process conformance in safety critical situations can clearly be undesirable.

The case studies have shown that change is an almost constant factor in many organisations. It is reasonable to suggest that in increasingly competitive business environments this shall remain the case. Organisations may wish to innovate to gain a competitive advantage over the competition or alternatively respond to the initiative of their competitors. For example Bank X may introduce a new kind of account with special services for a restricted subset of customers. Through process modelling new processes can be designed or existing ones altered to support the account. As soon as this account looks like being profitable Bank Y may wish to introduce a similar account.

Process modelling should contribute to the harnessing of change for the benefit of the organisation as a whole. It should enable positive change. Change should become better understood, more focused and less likely to be a symptom of badly drawn procedures or rules. Detrimental change should be prevented through enforcement (e.g. designing support systems that require the user to go through all safety checks), or by ensuring that processes are sensibly designed and well understood in the first place.

Harnessing change in this way requires that the following research agenda is addressed:

- The phenomenon of change needs to be better understood. For example, how do different organisational characteristics affect the likelihood and type of change? Do organisations sometimes become stagnant (without change)? How does the frequency of change affect other organisational attributes such as product quality or

job satisfaction? To what degree of granularity do we need to consider process change?

• A means of classifying change needs to be developed. The positive/ detrimental change model used above is too simple. For example, how would deviation from safety critical processes be classified where the informal, deviant process is actually safer than the official process?

• Modelling tools which inform the manager and staff of how work is done need to be developed. These should assist the use of process modelling as a continuous, non-terminating process in the organisation.

• Support technology needs to permit flexible working and to be easy to change. Given that change is a feature of everyday organisational life it is a paradox to claim that an IT system supports a process if that system is difficult to change.

The introduction to this paper referred to Lucey's characterisation of organisations through the keywords "goal oriented," "social systems," "groups," "technical systems," "structured activities" and "people...coordinate." None of these features is static, all are dynamic. Morgan [Mor86] addresses the phenomenon of organisational change many times through different metaphors. For example we might view an organisation as a brain which learns and through "..rich connectivity between similar parts...can create systems that are both specialized and generalized, and that are capable of reorganizing internal structure and function as they learn to meet the challenges posed by new demands." The phenomenon of organisational change is a challenge for process modelling but even more it is a vindication of its adoption. Through process modelling the interaction of people and groups can be explored, repetition and predictability of actions can be shown, actions can be related to one another and the functions undertaken by technology can be shown in a broader human oriented context. This understanding can then be used within the organisation to make changes for good purpose and to meet new demands.

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