REDUCING REWORK IN THE DEVELOPMENT OF INFORMATION SYSTEMS THROUGH THE COMPONENTS OF DECISIONS

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Abstract: The failure of information systems has been partially the result of incorrect or inefficient rework in the development of the systems. If greater transparency can be made in the decision making process then the number of examples of incorrect or inefficient rework could be reduced. Transparency in the process of development can be achieved through identifying and tracking the components of the decisions made during the development of the information system. This paper presents a theoretical framework for facilitating this tracking by comparing the components of the decisions in the development of the information system with those of an organisation and considering how the 'needs' of agents and the actions taken to fulfil those needs are related.

1 INTRODUCTION

This paper presents an approach for reducing rework in the development of information systems through the increased transparency of decisions. This transparency is achieved by tracking the components of decisions made at different organisational levels or involving different agencies in the development of an information system.

This paper introduces the concept of viewing the components of a decision rather than the actual process of decision making. The model proposed here is intended for use in a decision support system, not in the form of a system to provide alternatives and dictate the choice of optimum actions, as for example IBIS (Kunz and Rittel 1970, Touchstone Consulting Group 2003), but through the ability to track the components of a decision. Tracking the components can reveal: whether the action specified in a decision has been taken, the agents responsible for initiating the decision and taking the actions specified, the need addressed by that particular decision, and the reason a particular action was chosen. How can this be used in the design of an information system to reduce rework? Decision making is generally considered by managers, and the academic discipline of management, to be central to organizational activity (Fulop *et al.* 1999, Power 2002). There are several reasons why decision

making is considered to be so crucial: the need to formalize and codify management work, to promote communication between managers and others in organizations, and to be able to justify a selected course of action from the range of likely or perceived options.

A need that is becoming more apparent in systems engineering projects is to reduce rework whilst maintaining accuracy and the integrity of the project. In many cases rework is occurring as a result of communication failure between decision makers, often resulting in inappropriate or incorrect decisions. Rework involved in the making of decisions could be reduced if the agents concerned had available to them a means of tracking decisions which had been made and the actions which result from those decisions (Rayson *et al.* 2003).

Section 2 of this paper considers the components of decisions and how the same components are apparent in different models of decision processes. Sections 3 and 4 introduce the links between agents, needs and actions and how these occur in organisational contexts. Section 5 explains how the models can be used in the tracking of decisions. Section 6 provides a discussion of the resulting model and how it might be used.

2 COMPONENTS OF A DECISION

Simon (1960) describes decision making as comprising three principal phases: *intelligence* - finding occasions for making a decision, *design* - finding possible courses of action, and *choice* - choosing among courses of action. These three phases are also reflected in the model of Jennings and Wattam (1998) where they are termed: *identification*, *development* and *selection*. In the model of Adair (1985) decision making involves a five-point plan which contains the following stages:

1. Define Objectives.
2. Collect Information.
3. Develop Options.
4. Evaluate and Decide.
5. Implement.

The five stages of the decision making process can be combined with two further stages:

6. Sense Effects.
7. Monitor Consequences.

The seven stages make up a continuous cycle in which an agent perceives its surrounding environment, defines objectives by which it intends to change that environment in some way, collects information about the environment and the actions that are available to it. The agent can then develop options about how it will be able to influence the environment, evaluate each potential action and decide which, if any of the options it is going to enact. The chosen action is implemented by the agent, or a different agent on the behalf of the implementing agent. The environment of the agent is continually monitored and any changes which are sensed by the agent, including those initiated by the agent and enacted by other agents, leads to the definition of further objectives and continuation of the cycle. The result is a continual feedback loop of perception, action if required, and evaluation as shown in figure 1. A similar pattern is presented in the seven steps of the General Decision Process Model reported by Power (2002).
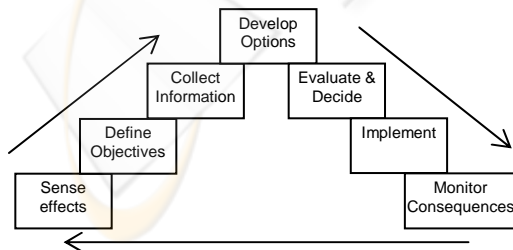

Figure 1: Model of the decision making process, from Adair (1985)

The stages of the decision making model shown in figure 1 are reflected in other models of decision

making, for example, the normative model of decision making, as reported by Jennings and Wattam (1998), and the rational decision process as indicated by Fulop *et al.* (1999) shown in figure 2.
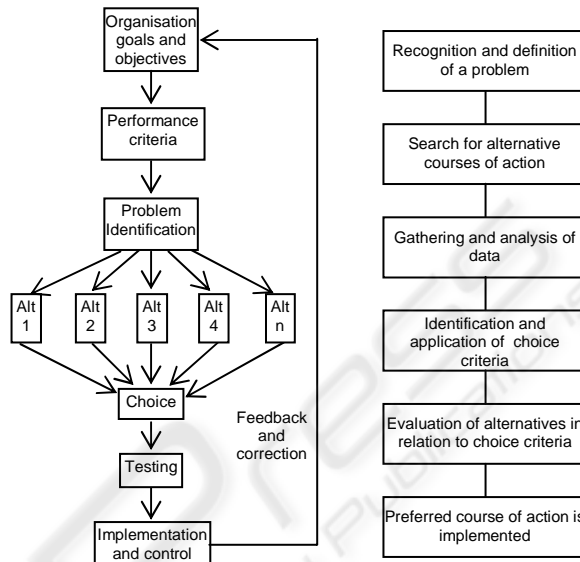

Figure 2: Models of the decision making process: Normative (left) from Jennings and Wattam (1998) and Rational (right), from Fulop *et al.* (1999)

Rather than examining in detail the stages of the decision process which involve choice and evaluation, how agents choose between different alternatives, we are interested in all the different stages of the decision process and the components which are utilised or generated at each stage. These components can be identified as existing in each of the different models of decision making. The components we have identified and the links between the components and the models of the decision making processes are shown in table 1.

Table 1: Comparison of components in the decision making models

component	Adair (1985)	Jennings & Wattam (1998)	Fulop *et al* (1999).
information	sense effects		
need	define objectives	goals & objectives	recognition of problem
potential action	develop options	alternatives	gathering & analysis of data
choice	evaluate & decide	choice	evaluation of alternatives
selected action	implement	implement-ation	implement
report	monitor consequences		

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The components involved in a decision process can be linked to agents, their needs and requirements in fulfilling goals, either their own or those of the organisation for which they work, and the actions required to fulfil the needs.

3 AGENTS, NEEDS AND ACTIONS

An agent can be identified as a single entity or as two or more individual agents acting together towards a common goal, for example a group, a department or an organisation. As stated in the previous section, these agents have 'needs', conditions in their state of affairs which remain unfulfilled, identified as: 1) a lack of something requisite, desirable, or useful, 2) a physiological or psychological requirement for the well-being of an organism (Merriam-Webster 2003).

To fulfil these needs the agent must take some action that changes the state of affairs. Having made the change the agent can perceive and interpret the changes, evaluate the new state of affairs and decide if the needs which prompted the action have been fulfilled. If, through this sensing of the environment, it is identified that the needs have not been fulfilled, or that further needs have arisen, the agent can identify new goals and perspectives requiring further action.

Changes in a state of affairs occur through actions, an agent acting on its environment either in a substantive way (through physical action) or communicatively (through discourse). Thus an agent may have a need for a particular component for a project, which is fulfilled by the action of obtaining the component. An agent may have a need for information which is fulfilled by linguistic communication with another agent in the form of reading, listening or observing. The links between agents, needs and actions are shown in figure 3.
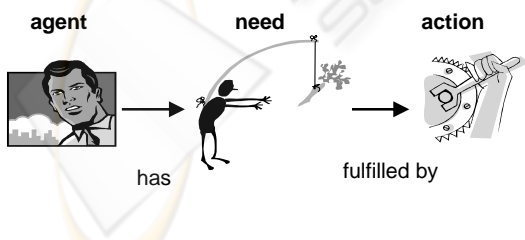

Figure 3: Agents have needs which are fulfilled by action

An agent can have none or many needs, each of which can be fulfilled by one or many actions. The definition of need implies that they cannot be fulfilled without some form of action. One need may be fulfilled by one of a number of different actions.

For example, to fulfil the need for sustenance, an agent might go to a restaurant and order a meal, buy sandwiches in a supermarket or simply drink a glass of water. One action may fulfil several needs and the fulfilment of a need itself may lead to further needs. For example, the purchase of a car fulfils the need of a comfortable mode of transport but leads to a further need for the purchase of petrol, insurance and other consumables with which to run the car.

An action always involves two agents which may or may not be the same. The action is initiated by an 'initiating' agent who communicates with an 'acting' agent who carries out the action. The communication with the acting agent acts as a trigger for that agent to take the action specified as the means by which to achieve the state of affairs. In order to carry out the action specified to fulfil the need of the initiating agent, the acting agent itself may have needs, which require action on the part of that agent or another. Figure 3 can thus be redrawn as shown in figure 4.
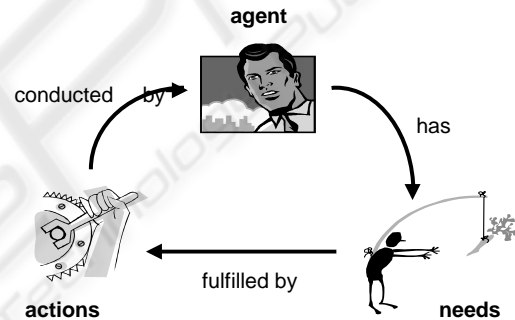

Figure 4: The agent, need, action loop

The loop acts recursively, each agent developing needs which can be fulfilled by action on the part of further agents until a point is reached where the needs of an agent are satisfied by action on the part of that agent itself.

4 AGENTS, ACTIONS AND NEEDS IN AN ORGANISATIONAL CONTEXT

An organisation can be considered to consist of individual agents working towards a common goal. A number of agents may combine to form a group which can itself be considered as a single agent. Thus the 'board of directors', which consists of a number of individual board members who can act independently of the board, can be considered as an agent. The board has needs and it can initiate actions

in other agents by which these needs are fulfilled. The different groups of agents can be seen to make decisions relating to three different levels of effects on the organisation:

1. Strategic.
2. Tactical.
3. Operational.

Each of these levels can be seen to have different needs which will be fulfilled in different ways. For example, Jennings and Wattam (1998) state that strategic decision making is a central part of the management of an organisation. Strategic decisions and the statements these strategies deliver provide:

1. The fundamental means by which the organisation seeks to achieve goals.
2. Purpose in relation to the internal world of the organisation - shared strategy helps reduce uncertainty and promotes consistency of decisions.

Strategic needs can be fulfilled by tactical action requiring tactical decisions. Tactical decisions address strategic needs by optimising the organisation's performance within the predetermined strategic direction. Examples of tactical decisions include the selection of new marketing programs that bring renewed focus on the targeted customer segments and providing a web-based promotion/distribution platform to extend reach and radically reduce cost (Lam-Po-Tang 2003). Tactical decisions require action on the part of agents to fulfil the resulting tactical needs, these are operational actions requiring operational decisions. Operational decisions address tactical needs through substantive actions, specific actions with a substantive result. Agents responsible for carrying out operational actions may have no need to make further decisions as the actions to fulfil their needs are immediately available.

The details of actions derived at any of the three organisational levels can be specified using information derived in the form of W5H:

i. Who - in or outside the organisation (sub consultants, contractors) is to carry out the action.
ii. What - is to be achieved in carrying out the action.
iii. Why - the action is required, specified by the need, it can thus be the same 'why' for several actions.
iv. When - in time the action is to occur.
v. Where - physical location at which the action is to occur.
vi. How - the communicative or mechanical process that is to occur.

The who contained in the specification of the action refers to the agent that is going to carry out the action. A decision implicitly or explicitly contains details of a second 'who' which relates to the agent initiating the action. This is the agent that has the 'need' which the action is attempting to fulfil and the agent that supplies the 'why' for the action. The details of the actions to be taken can be combined with the information on the organisational level to extended figure 3, as shown in figure 5. Who(I) represents the initiating agent, the agent with the need. Who(A) represents the acting agent, the agent that will carry out the action in attempting to fulfil the need.
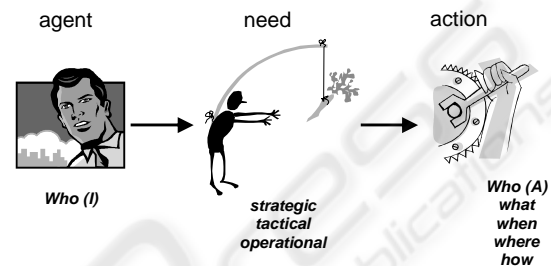

Figure 5: Organisational levels and information derived in the agent, need, action model

Decisions devolve through the organisation - needs at a strategic level are addressed at the tactical level, needs at the tactical level are addressed at the operational level. The triangular model of figure 4 can be represented as a spiral model, shown in figure 6a. The acting agent at one level - Who(A) becomes the initiating agent for action at the succeeding level - Who(I). At some point an agent does not need to make a decision, it can take an action, for example getting a component off the shelf which fulfils the need of the agent without recourse to involving further agents.

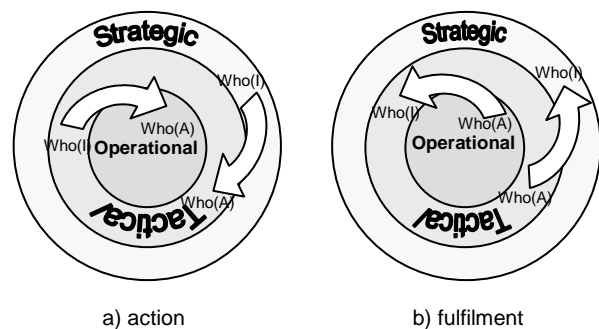a) action   b) fulfilment

Figure 6: The organisational decision action (a) and fulfilment (b) spirals

If action is taken then the spiral is reversed, each action taken fulfils the need of the initiating agent as shown in figure 6b. Further decisions may be required on the basis of the action taken to fulfil the need of an agent. Thus if action taken at the operational level does not fulfil a need at the tactical

level then a decision may be made to rework the action, to take alternative action to fulfil the need.

5 COMBINING THE MODELS IN THE TRACKING OF DECISIONS

The model of components of decisions can be combined with the model of agents, actions and needs to provide a model which can be used for tracking decisions and the components of decisions, and thereby providing a facility for reducing the possibilities of rework. The information regarding the various components of decisions can be identified and recorded from minutes or transcripts of meetings. The components can be identified through the use of text analysis which identifies issues in the form of topics and, for example, actions within the issues through the identification of natural language terms (Rayson *et al.* 2003, Chibelushi *et al.* 2004). Components can be identified by keywords, issues or topics which could be used to link components of decisions across a number of meetings. The complete set of components for a decision will not be revealed in a single meeting, the action and therefore the report must occur at a time later to the evaluation of alternatives and choice.

The components of a decision were identified in section 2 as information, need, potential action, choice, action selected and report, however, for many decisions only a kernel of the components are identified, which consist of the need, the action taken to fulfil the need and the report.

Information leads to a need on the part of an agent identified as the initiating agent - Who(I). The why of an action (why it is being carried out) identifies the need. Potential actions are identified and specify as a minimum the acting agent - Who(A) and what the agent is to do. The specification of the action may include when the action is to be done by, how and where it is to be done. These potential actions form the alternatives. Discussion and choice forms the next component of the decision, recording this information gives the reason why a particular action was chosen from amongst the alternatives. The selected action specifies the Who(A), what, where, when, and how. A report makes up the final component of the decision, has the action been carried out, what was the result? The report may then provide further information leading to the start of another decision.

The model provided here is not intended to provide alternatives and assist in the choice of alternatives as the solution to an issue, as in for example, IBIS (Kunz and Rittel 1970, Ullman 2001, Touchstone Consulting Group 2003), HERMES

(Karacapilidis and Papadias 2001) or SYBIL (Lee 1990). The model is intended to provide the basis for developing a facility for tracking the components of decisions, it adds transparency so that those with access can find out whether an action has been enacted and reported on. If an action does not occur then it may be possible to identify why not and which alternative actions were made available at the time. If an action has not been taken by a certain time then the need that action addresses may not have been fulfilled. If a decision to take a particular action has been made but the action fails, the alternative proposals can be reviewed without the necessity of going through all of the discussion and searching which lead to the alternatives in the first case.

Being able to track the components of decisions assists in reducing the amount of rework that occurs in organisations by increasing the transparency of the decisions and making available the components which were involved in the whole decision process. In the development of an information system, the reasons for selecting a particular action or component can be reviewed. The selection of particular components, the reasons for these selections and their effects can be viewed with respect to other sub-systems reducing duplication of work. This can be either reducing negative rework, by preventing a repeat of bad practice, or positive rework, using beneficial effects in one sub-system to enhance another. Unfulfilled needs can be quickly identified revealing where further work may be required before a situation arises in which large elements of work need to be readdressed.

The model is being implemented through the application of a software tool which allows the different components of decisions to be recorded and searched for links between the components.

6 DISCUSSION

Some validation of the model has been carried out using data in the form of minutes from a series of meetings, however, the model needs to be implemented across an extended data set. The long time scales over which strategic decisions are made and implemented requires a longitudinal case study to determine if decisions and the components of decisions can be tracked over an extended period of time. Minutes of meetings provide only a limited source of data with regard to the components of decisions. Needs, the reason why particular actions are chosen, are seldom represented and development is being undertaken to identify needs, issues and actions directly from transcripts of meetings. By

linking the actions to needs expressed within a decision, the reasons for taking particular actions are available, this may reflect on rework when issues are readdressed. Identifying the initiating agent allows responsibility to be allocated for decisions and accountability made available. If an action has not been taken (or has not been reported) then rework can be avoided by making sure the reasons for the action not occurring are not repeated. The method could also provide decision support outside the project in which it is being used. By having the range of decisions available including information on initiating and acting agents it would be possible to evaluate which parts of an organisation are being over or under utilised and where financial and material resources need to be allocated.

7 CONCLUSION

This paper has proposed a method by which we can approach the issue of rework related to decision making in organisations and the development of information systems. The method can be used to provide a decision support system of a form which gives information regarding completed decisions and the links between decisions, rather than proposing alternatives and strategies for choosing between alternatives. The issue of tracking decisions is addressed by identifying a number of components into which decisions can be decomposed. The components are related to the stages which have been identified in decision making processes. Agents, which can be defined as individuals, groups or organisations, have needs which can be fulfilled through actions, either by the agent itself or other agents acting on its behalf. The agent which is to carry out the action may itself have needs with regard to the action which are fulfilled by actions on the part of further agents. This agent, need, action loops recur until a position is reached in which an agent can fulfil its needs without recourse to a decision. Once this point is reached the actions occur in a reverse spiral, the decisions at each level being fulfilled by the action occurring in the previous level.

By identifying the components of decisions it is possible to determine if all of the stages involved in a decision have been completed. With greater transparency in the decision making process, the result of identifying if stages are missing or incomplete, rework can be identified and avoided if detrimental in its effects on the project, or recognised and implemented across further aspects of the project if the result is beneficial.

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