A LIFE-CYCLE DECISION-INFORMATION MODEL ACCOMMODATING COMPLEXITY IN PROJECT PROCESSES

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ABSTRACT

Fragmentation and barriers to information flows between project participants has been a major obstacle to productivity quality in the construction industry. Strategies to overcome this needs to contend with the interaction between numerous project participants which generates considerable complexity in project dynamics.

A "soft" technology approach has been advocated to managing the coordination and communication of project participants. A dynamic framework to provide integrated decision support to project participants has been previously described.

As an extension to the development of this framework, this paper describes a conceptual approach which perceives a project as an integrated collection of decisions. The project development process is modelled as a dynamic decision-information flow system operating across the project's life cycle. The recognition of individual decisions as system components allows information sharing in a near real-time context, which would facilitate an integrated project process. Feedback processes in the model provide a framework for accommodating complexity in the project process.

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INTRODUCTION

The construction industry involves a wide range of different activities and specialist participants from the design and pre-design stages of projects through to the construction and maintenance of the completed product. Each of the different activities generates and/or uses information and the different participants need to engage in an effective communication network so that relevant information flows are not impeded. In reality, the fragmentation and barriers to effective flows of information between participants has been a major obstacle to productivity and quality in the industry (Mathur and McGeorge, 1993; Royal Commission into Productivity in the Building Industry in New South Wales , 1992).

The development of computer technology in the building industry has largely resulted in improvements within the specialist functions. Arguably, this has exacerbated the separation between specialist functions. At the same time, the technology also offers the technical means to promote coordination and integration between different participants and functions. The development of "hard" technology which largely results in improvements in specific functions needs to be matched by the ability of decision takers to maintain and improve coordination and integration across these functions.

We have envisaged the adoption of a "soft" technology approach which would allow different participants in the system to exploit the potential of computer interrogation of electronic stored information and are developing a dynamic framework to provide integrated decision support for participants at project level through its life cycle. A "top-down" conceptualisation of this framework has been previously described (McGeorge, Chen and Ostwald 1994).

To exploit the full potential of such a concept, the framework needs to facilitate "real-time" communication and coordination between project participants through all the stages of the project life-cycle. This requires a model which is able to accommodate the potential complexity of the project dynamics in the project.

ABSTRACTING A DYNAMIC LIFE CYCLE PROJECT MODEL

Project processes involving many independent agents interacting with each other in many different way create situations of great potential complexity. The behaviour of each agent, while directed at the project objectives, is also influenced by their own agenda determined by a web of "incentives, constraints and connections" (Groak, 1992). The behaviour of these agents is continually modified by learning, social evolution, technological innovation, competition and cooperation (Waldrop 1992). This combined with the many different approaches to project procurement, and the unique contextual environments within which any project could be manifested, produces a range of possible scenarios which is impossible to predict.

Project participants contribute to the project process through many different functions but ultimately their contribution may be represented by decisions which affect in some way the direction of the project process and the nature of the project product. Building project processes consist of concurrent and sequential flows of decisions. The evolving building product can be seen to be represented by a progressive accumulation of decisions.

Using project decisions as the basic elements for modelling a building through its life cycle is an extension of the concept of an "integrated project description" (Leslie, 1992; Chen et al, 1993). A project description is the representation of the project in terms of all the decisions which have been made in the project process to date. At an early stage of feasibility assessment, the project description could be a statement of all project objectives which has been identified and which might form the basis for a design brief. At various later stages of the project life cycle, the project description may be manifested in different and fragmented forms such as sketch design drawings, working drawings, specifications, bills of quantities, shop drawings and as-built drawings. The use of computerised tools for communication and coordination would allow the development of a singular integrated project description which all project participants are informed by and contribute to.

A decision-based model of a project can embody all the complex connections and dynamics between project participants without needing to make these explicit. It provides a level of abstraction which allows individual participants to work with a finely-grained representation of the project through its life cycle.

PROJECT DECISIONS

Project decisions to be used to model a project need to be clearly defined and identifiable. They should be distinguished in the first instance from ideas, thoughts and interim tasks which individual participants work through to arrive at decisions. Project decisions are those which are externalised and capable of being communicated to other participants. They should have one or both of the following attributes:

a) add information to the project description,

b) trigger one or more activities including further decision making in the project process

Even when project decisions are distinguished by either of the essential attributes, there will still be a wide range of different types of decisions to contend with. Not all project decisions are essential in an integrated product description and others are subsumed by later or overriding decisions. It is useful therefore to develop a taxonomy of project decisions which is relevant for the proposed model and identify their characteristics.

In the first instance, project decisions may be classified either as end decisions or transitionary decisions. End decisions are those which contribute to the project description. Conclusions arrived at through planning and design activities are examples of end decisions. Transitionary decisions are necessary to trigger activities or further decision making. These have an essential enabling function to enable the project process to progress. Examples of transitionary decisions include the instruction of consultants, contractors and other project participants, checking and approval of interim and completed work and so on. Broadly speaking, end and transitionary decisions relate to "product" and "process" decisions in the project.

End decisions may be further characterised as stable or unstable. Stable decisions are relatively enduring through the project life cycle while unstable decisions are subject to change, revision or being superseded by later events. It is not important that the distinction between stable and unstable decisions be clearly made or maintained as unpredictable events may well come into play to change one to the other. The characterisation is useful to introduce the notion of currency and endurance in a dynamic process. Many design decisions at conceptual design stage may be regarded as unstable because they are subject to change through later stages of design development.

The proposed project decision taxonomy is illustrated in Fig. 1.

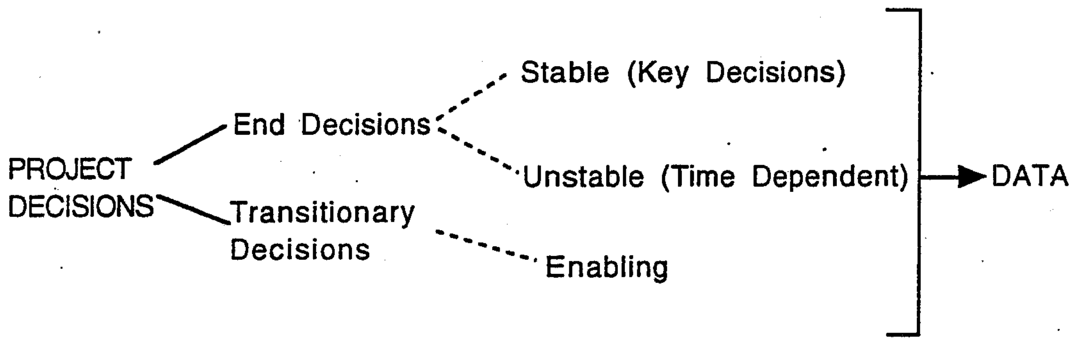

Fig. 1 Project Decision Taxonomy

All project decisions embody information about actions or intentions and thus provide data about the project and the project process. Some of these data are captured by formal documentation processes while the rest may reside in memories, personal or informal records or be lost. Stable end-decisions which are recognised and captured in the formal project system are identified as key project decisions. These key decisions and their embodied information generate the integrated project description (Fig 2).

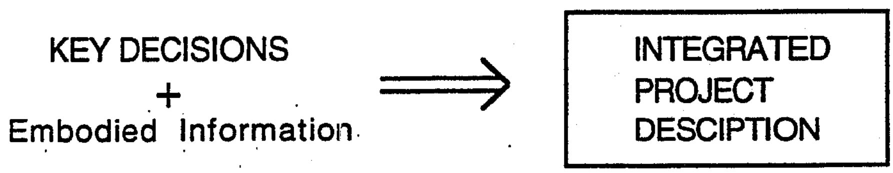

Fig. 2 Integrated Project Description

Project data provides feedback for the project decision makers. Not all the data would always be useful in this feedback function. The non-useful data may be regarded as "noise" and relevant data as information. The role of information in feeding back to decision makers is twofold. One is to initiate or trigger another decision making process and the other is to influence or shape future decisions. For example, architectural design decisions can both trigger and shape structural design decisions (Fig. 3).

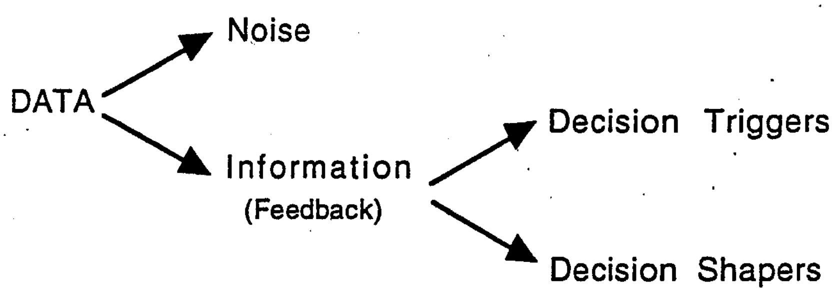

Fig. 3 Project Data as Feedback

THE MODEL

Fig. 4 illustrates a decision-information model of a building project which focuses on the decision and information flow generated by project decision makers through the project's life cycle.

This theoretical model recognises the relationship between the project as a system and its external environment. In this instance, the project's system boundary is defined by the project participants who are identified as project decision makers. This is a dynamic and flexible boundary. The project decision makers are constantly interfacing with and influenced by data exchanges with the external environment. It could be suggested that all projects are started by some opportunistic interaction between an agent and the primordial soup of existing external data which spontaneously triggers the first project decision.

Once the project process is "bootstrapped", project system boundaries come into being which give the project its identity. The project decision process selects, transforms and generates data which is then identifiable as project data. The accumulating pool of project data contains active elements which feedback into the project decision process, and non-active elements which may be regarded analogously as archived, perhaps to be activated at some future time.

Two important feedback loops are identified in the model. Project decision makers respond to cues and directions provided by preceding decisions. Communication of relevant information from project data acts therefore as triggers for further decision making and thus have an important coordination role as well. Future decisions may

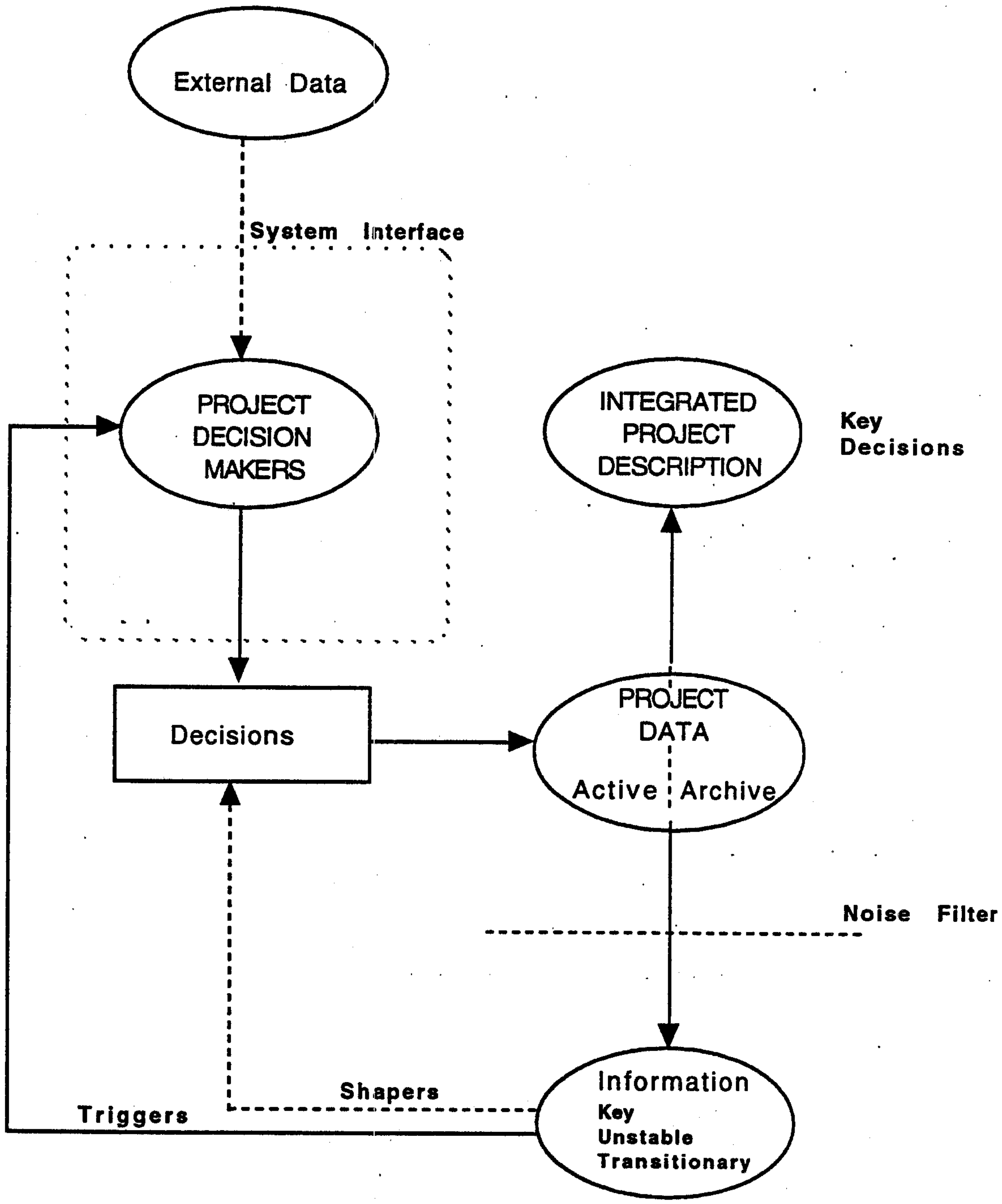

Fig. 4 Project Decision/Information Model

also need to take into account the existing status of the project. The function of information in the second feedback loop is that of "shaping" future decisions.

Key project decisions and their embodied information can be drawn from the project data set to provide an integrated project description.

The model provides for an on-going project process with project decision activity energised by the inputs from the external environment and decision triggers from within the environment. The project process can be stopped by a terminating decision which triggers a suspension of decision activity by the project decision makers.

DISCUSSION

The purpose of the proposed model is to describe the progressive status and development of a building project resulting from the collective and integrated inputs from project decision makers through the project's life cycle. It provides a conceptual mechanism which would allow "real time" coordination and communication between networked project participants through a continually updating integrated project description.

The model described provides a simple and robust representation of a project in terms of decision and information flows through all stages of the project's life cycle. The focus on the net decision and information flows rather than the activities of and the connections between individual decision makers accommodates the complexity of inter-agent dynamics operating in uncertain project environments and the combinatorial explosion of possible outcomes.

Complexity theory suggests that at the root of all complex systems lie a few simple rules. The "bottom-up" perspective of the proposed model elucidates rules governing the decision and information flows of the model which are simple but capable of generating great complexity.

The robustness of the model derives from the "softness" and flexibility in terms of the boundaries and elements of the model. The interface between project decision makers and the external environment can be set according to the unique circumstances of any project. The "magnitude" of each discrete decision to be identified in the model can be as microscopic or aggregated as is necessary and practical. The "soft" approach taken by the proposed model gives it conceptual potency.

CONCLUDING REMARKS

The information technology revolution has directed the attention of the construction industry towards the integration of information in all stages of the building life cycle as the key to greater efficiencies and improved productivity. The use of "hard" deterministic and reductionist strategies is often frustrated by the complexity inherent in project situations especially when universal models are called for.

The emerging "science of complexity" (Pagels, 1988; Lewin; 1993) is pointing to the need for new "tools of thought" (Prigogine and Stengers, 1994). It is suggested that "soft" and simple models provide such tools for recognising and accommodating complexity in projects.

REFERENCES

Chen, S.E. and McGeorge, W.D. (1994), "A systems approach to managing buildability", The Australian Institute of Building Papers, Vol 5, pp. 75-86

Chen, S.E., McGeorge, W.D. and Ostwald, M.J. (1993), "The role of information management in the development of a strategic model of buildability", The First International Conference on the Management of Information Technology for Construction, Singapore, August, 1993

Groak, Steven (1992), The Idea of Building, E & FN Spon, London

Leslie, H. (1992), An Information and Decisions Support System for the Australian Building Industry, NCRB, Melbourne, Victoria

Leslie, H.G. and McKay, D.G., (1995), Managing Information to Support Project-decision making in the Building and Construction Industry, CSIRO & NCRB, Melbourne, Victoria

Lewin, R. (1993), Complexity: Life on the Edge of Chaos, Phoenix, London

Mathur, K. and McGeorge, D. (1993), "Holistic problem solving for design innovation", ICEC International Conference, Singapore

McGeorge, W.D., Chen, S.E. and Ostwald, M.J. (1994), "A dynamic framework for project decision support - Developing "soft" interfaces for the management of construction projects", CIB W78 Workshop on Computer Integrated Construction, Espoo, Finland

Pagels, H.R. (1988), The Dreams of Reason, Simon and Schuster, New York

Prigogine, I. and Stengers, I. (1985), Order out of Chaos, Flamingo, London

Royal Commission into Productivity in the Building Industry in New South Wales (1992), "Reports of hearing - Royal Commission into Productivity in the Building Industry in New South Wales", Government of New South Wales, Sydney

Waldrop, M.M. (1992), Complexity, Penguin, London