The Generic Metamodel, the Conflict Modelling Cycle and Decision Support

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Abstract

Metamodels provide a mechanism for guidance in modelling. They offer a structured approach, which is appropriate for the modelling of situations and processes. An example of a metamodel is a modelling cycle, and one is proposed suitable for conflict processes in groups with critical size. The way in which such a modelling cycle can be implemented on a computer system for decision support is discussed.

1. Introduction

This paper is concerned with the modelling process of conflict which arises from change, and the simulation of that process. The modelling of modelling processes is a metamodelling process, providing guidance and structured reasoning to situations that may be somewhat messy in the way in which they are defined. Thus, this paper is concerned with metamodelling, and in particular it concerns the structured modelling of conflict arising from change for large groups. It also has interest in the computerisation of such modelling.

When attempting to model, and thus examining the conflict processes of groups, it is appropriate to differentiate between those which are small and those which are large: small groups tend to be ill-structured in their communications and decision processes, that is they do not conform to a predeterminable pattern or relate group entities in a predeterminable way. Larger groups tend to be more structured, having formalised processes and entity relationships that are better known and more predeterminable. Thus, the structural nature of groups under change itself changes according to the size of the group within which it occurs. Small group processes tend to operate differently from those of large groups. They mostly operate informally and are unstructured. A group can be thought of as becoming a large group when it has acquired a critical mass of people. Like so many examples in real life that can be described as having an instantaneous metamorphosis [Thom, 1975], the critical change that distinguishes small group processes from large group ones may well appear to be sudden and distinct. However, as groups get larger, so group norms start to appear; as they increase in size, so too does the complexity of their relationships, communications, and other processes. With this formalised processes start to develop, and the group thus becomes more structured and more easily representable by formal models.

Models can be classified on a *hard* to *soft* continuum. In hard models *things* tend to dominate a problem and its setting, while in soft models it is *people* and their psychological needs that dominate. In very soft contexts, the model may become the activity. For example the named conceptual domains of Systems Engineering, Project Management, Systems Analysis, and Operational Research are closer to the hard end of the continuum while Management Cybernetics, Soft Systems Methodology, and Organisational Development are closer to the soft end. Harder approaches tend to adopt more externally structured elements within their operational frameworks than the softer approaches which tend to be more unstructured. Domains that are highly structured have elements that are explicitly well defined and can more easily be modelled. Thus, in systems engineering it is the norm to model and where possible test a solution before implementing it, while in Organisational Development, the only way to test a model is to experience it.

The approach to modelling conflict processes is frequently better undertaken when guidance in creating and validating models is provided. This represents a structured approach. In particular, it is important that the approach to a problem being modelled is to be well structured. This can often be accomplished through the use of a modelling cycle, and modelling cycles are representative of metamodels. One purpose of this paper is to consider a modelling cycle which is directed at large group conflicts.

When considering computer aided application of a metamodel to a problem domain, the softer the problem, the more difficult it is to generate a computer system able to adequately deal with general modelling and simulation requirements because of the need for machine intelligence, level of knowledge, and decision making facility needed.

2. Modelling Cycles

Simon [1960] was a major contributor to Management Science. His concern lay in the development of a decision science, and in order to do this he expressed the prevalent ideas on modelling development as a general cycle for decision making processes under goal seeking behaviour. Its three phases are *Intelligence*, *Design*, and *Choice* which can be iterated through to progress a problem. The cycle provides guidance in modelling decision problems which tells us that problem domains must be properly examined, options identified, and models generated and applied to the domains.

The Simon cycle has provided guidance to the process of decision making. However, it does not provide model builders with direction about model building techniques or approaches, nor provide a philosophical orientation for so doing. A development of this cycle was suggested by Rubenstein and Haberstroh [1965], and a variation designed for computer software developers was later produced [Sprague, 1986] in order to tackle well structured problem domains. The latter hard approach come out of the stable of Systems Development Life Cycle, and this type of approach has been used in situations in which the analyst does not envisage the involvement of people while addressing the problem domain. It therefore provides for a highly structured modelling approach that can be represented in terms of well defined harder modelling techniques. To tackle more unstructured processes involving people a different need arises.

One well known metamodel [Checkland, 1981; Checkland, Scholes, 1990] called Soft Systems Methodology (SSM) has been used to solve unstructured small group dynamic change problems. The philosophical stand of SSM, however, is strong is demanding conformity to the way in which the cycle operates, and suggests that consistent with soft perceptions, solutions to problems cannot be modelled but rather must be experienced.

Some authors perceive that while SSM provides a sound approach towards the solution of problems of change, it is constrained in its breadth, since its philosophy of operation is very specific. Flood and Jackson [1990] have defined their more flexible metamodel which introduces the idea of a "metaphor" to represent an analogous concept to the problem in hand. The metaphor thus helps to identify the context of a situation. This approach has been called Total Systems Intervention (TSI), and consists of a cycle of three phases: *Creativity*: use system metaphors as organising structures; e.g. see an organisation as a machine (closed system), an organism (open system), a brain (learning system), culture (norms, values), team (unitary political system), coalition (pluralist political system), or prison (coercive political system). Outcome is the dominant metaphor. *Choice*: select an intervention strategy or set of methodologies as appropriate. Use any of the tools available from the hard-soft continuum of techniques. A dominant technology may be found. *Implementation*: employs a particular system methodology to translate the dominant vision of the organisation, its structure, and the general orientation adopted to concerns and problems into specific proposals for change.

Common to the above metamodels, and indeed others, it is possible to generate a definition for a generic modelling cycle. The three phases that are defined are *Analysis*, *Synthesis*, and *Choice*. Analysis is the breaking down of a problem into its components, including its context, the identification of its structures, and its orientations. Synthesis is the building up of a set of components into a coherent picture, from the integration of ideas derived from the analysis, to the construction of the prerequisites for a model. Finally, Choice is anything that involves the selection of something, including implementation.

It is quite a simple matter to apply the generic model to any modelling cycle from the very hard Systems Development Life Cycle, to the quite soft Organisational Development cycle. The fundamental distinction between the different metamodels then becomes the philosophical approach. In principle, one can consider that the generic metamodel is held on a slide on the hard-soft continuum on which reside a variety of modelling/problem structuring tools, and as it moves it picks up those modelling tools it requires and appropriate philosophical approaches. Having completed a cycle, it is possible to move to another division on the continuum, also perhaps adopting a new philosophical position. This approach must implicitly hold flexibility in its philosophical stance.

3. The Conflict Modelling Cycle

In the social sciences, it is frequently the case that models are built in a way which is not structured. They could therefore benefit from the application of a metamodel. Models for such processes may vary in their position on the hard-soft continuum.

While the TSI approach could be useful here since it provides some level of flexibility, it does not appear to give guidance in providing a way of directly connecting the examination of the problem

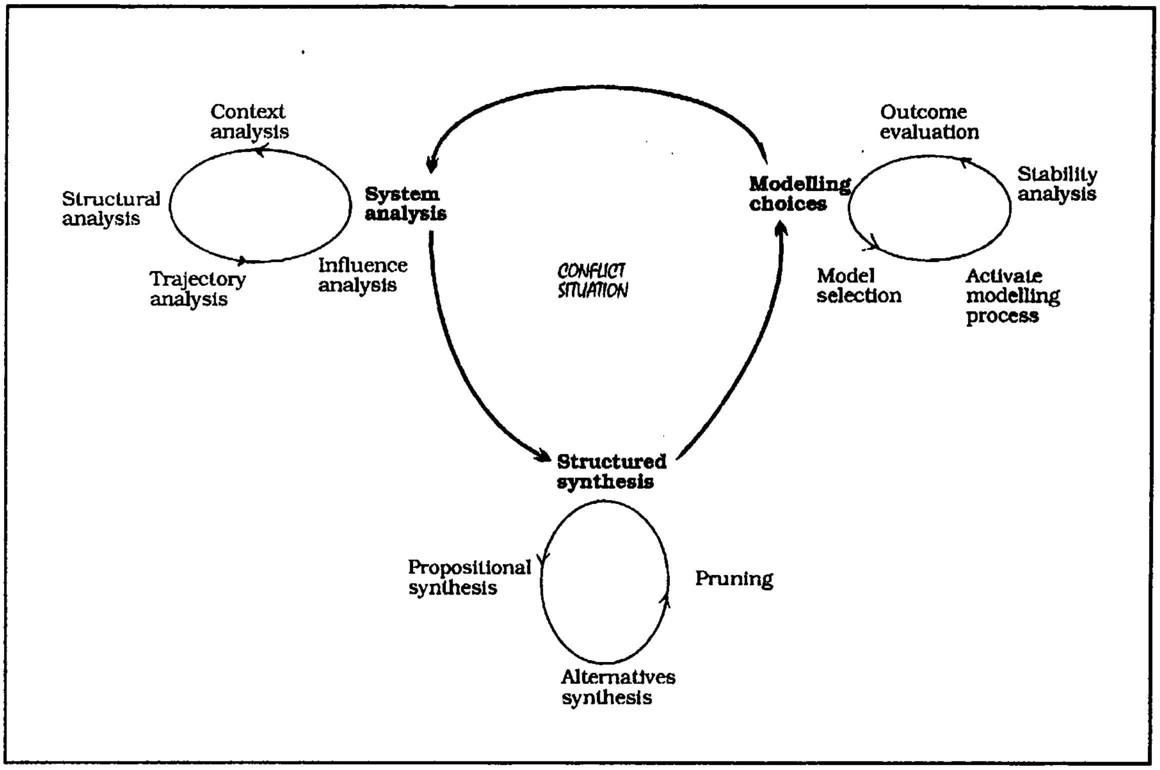


Fig. 1
Conflict Modelling Synthesis Cycle

domain with traditional hard modelling approachesas might be required in the semi-structured problems of large group conflicts.

In an attempt to address this type of problem domain, the conflict modelling cycle (CMC) presented in figure 1 adopts the three phases of the generic model. It is thus consistent with the Simon cycle, and broadly SSM and TSI, though necessarily the terminology and philosophy have changed.

In CMC, the first phase *Analysis* involves domain examination and evaluation. The second phase is *Structured Synthesis*, and involves propositional definition of the unstructured problem domain, and the structuring of decision alternatives. *Modelling Choices* is the third phase; it is concerned with the selection/implementation of modelling approaches which may be soft or hard. In the case of soft modelling the model defines the approach to a solution. In the case of hard models then this phase in addition addresses explicit model selection and evaluation, and ensures consistency between the propositional base of each of a possible set of models available for selection, and the propositions defined in phase 2.

3.1. Systems Analysis

Systems analysis requires that the problem domain is defined, examined, and analysed. Analysis is concerned with examining the system situation for actors and conditions which relate to the resultant states that must be defined and selected; data inputs are obtained, processed, and examined for clues that may identify problems or concerned with gathering data, identifying objectives, diagnosing problems, validating data, and structuring problems and environments. Systems may also be dynamically and structurally stable. Dynamic stability relates to the movement of a system in its achievement of desired goals. Here, a desired goal will be achieved as time passes if the system is dynamically stable. Necessarily, therefore, dynamic stability is time related. If a system has reached a goal and adheres to it, then the system has achieved a condition of equilibrium. Structural stability is more properly referred to as structural criticality. A system which is close to criticality may react significantly to a small change in one of its parameters. Under change, a system may pass through a critical condition, when its structural relationships alter. A big change caused by a small event shows the system not to be stable.

In terms of the conflict modelling cycle, the phase elements are defined in the following way:-

P1.1 Context analysis Examine the nature and context of the conflict in general terms, and the environment in which it operates. Identify the type of problem, i.e. hard (quantifiable or single solution) or soft (unclear solution), bounded or unbounded. Use techniques like mind maps, spay diagrams, force field analysis, relationship diagrams.

P1.2 Structural analysis Define the system at various levels; use system map techniques and define the nature and boundaries of actors and other entities. Use systems methodology to identifying domain structure and its description (e.g. boundary parameters, degree of boundary fuzziness, system entropy); identify actor problem perspectives. Identify general goals of the actor systems.

P1.3 Trajectory analysis Trajectory analysis is concerned with problem definition and the movements that are made in solving it. *Problem definition:* The problem domain is the problem and its set of actors, parameters, variables, and constraints. Clear definition of this can be difficult when there is sufficient complexity. In reducing complexity one then might: (a) examine the changes that may have invoked the problem, (b) identify the problem boundaries and associated parameters, (c) examine how many problems exist and whether they can be reduced to discrete sub-problems, (d) examine possible problem solving schedules. *Trajectory definition:* Each participant in the conflict is an actor with a framework of perception, perspectives to the problem, and decisions and actions taken which constitute a pathway through the domain. The pathway will have a direction which, if intended, represents the aim of the process, and identifies a set of vectors of movement. The trajectory is the set of vectors taken with the resultant goals that may be achieved. The difference between an intended and an actual trajectory is an indicator of how stable the situation is. Thus, if measures of achievable and intended goals, aims and objectives can be made, a measure of stability can be found.

The rationale and feasibility of actor trajectories should be evaluated in relation to earlier phase elements. Techniques like objective trees, and multiple cause diagrams can be used.

P1.4 Influence analysis Establish relationship between entities within the system and its environment. Use techniques like influence diagrams. This phase should reflect on P1.3 by suggesting influences for trajectory changes.

To undertake analysis, it is essential that actors and their influences are adequately understood. Actors have goals, objectives, strategies, and an external environment with which they interact. They have internal constraints as well as external ones, variables which include general cultural attributes. This applies to all classes of actor, whether they are enterprises, cultural groups, or nation states.

Culture, defined in terms of its attributes, determines the value attached to data and information [Yolles, 1992].

3.2 Alternatives Synthesis

By alternatives synthesis is meant selecting, inventing, or developing possible options or decision scenarios. It is effectively a design phase, and the development of decision scenario alternatives requires an adequate knowledge of the problem area and an ability to generate feasible alternatives.

In the modelling cycle, alternatives synthesis includes the following elements:-

P2.1 Proposition synthesis Formally define propositions relating to the situation. This can be important because parties to a conflict operate within their own distinct frameworks; whether one party acts rationally may depend very much upon the nature of the framework, and if conflicts are to reach satisfactory conclusions, it must be possible to map from one framework to another coherently. This in essence defines a principle of interactive relatively for the parties to the conflict. Propositional definition may usefully use established terminology (e.g. game theory) introducing terms like player rationality, closed games, stationary games. Alternatively in a softer approach, it can simply list the set of assumptions that are made in order to construct a modelling approach.

P2.2 Synthesising Alternative Structures Generate a range of options: these include player participation, and possible player choices which may be defined for the situation; include possible player state choices that may be feasible and player coalitions in an n-player system. This involves modelling interactive player relationships as definitive scenario possibilities. Decision table techniques are appropriate, as might be other decision related approaches like Pugh's matrix [1984] often associated with the Organisational Development methodology.

P2.3 Pruning Pruning is the reduction of the alternatives identified in P2.2. These will be unstable scenarios which, by their elimination, will reduce the alternatives to a core set of Optional

Reality State (ORS) scenarios. ORS are perceived options or modes of adaptation within the system, and represent the possible states in a systems which contribute to the definition of the system structure. Use techniques like expert evaluation or Conflict Analysis theory.

In general, this phase is concerned with the manipulation of data, quantifying objectives, generating reports, generating alternative scenarios, assigning uncertainties or values to alternatives. In very soft applications, it relates to reducing the tactical options available to a core approach.

3.3 Modelling Choices

Modelling choices involves identifying/selecting models capable of representing feasible decision scenarios from those options available. It includes the evaluation of model options and their ability to represent player environments and decision scenarios, and examination of the consequences of modelling option in respect of a changing environment. It is necessary to activate these models as a solution to the problem. This will generate outcomes which may be possible problem outcomes. The models can be validated and the outcomes evaluated in terms of the problem domain. In terms of the modelling cycle, this phase includes:-

P3.1 Model Selection Identify modelling options and approaches; identify methods for modelling perceived and hypothetical situations which might also model the future; provide the choice of selecting model alternatives; identify the model demands, constraints and perspectives explicitly; define model propositions, stability mechanisms, and propositional base including any normative assumptions. Evaluate models, comparing selected models to the real world situation, and identifying convergence between modelling options and real world situation - that is convergence with P2.1. In very soft applications, this step simply relates to adopting the core approach of P2.3.

P3.2 Activate Modelling Process Involve ORS scenarios from P2.3, and set up a modelling technique. Identify any additional parameter estimation or variable estimation requirements based on historical evidence, assemble data, and prepare process modelling components.

Generate modelling results. In the case of stochastic modelling processes, approaches like Monte Carlo simulation, Markov processes, or Weibull games (see section 6) can be adopted, and perhaps compared. The application of models involving normative mechanisms must be connected with P2.1. In soft problems this step relates to starting the experience.

P3.3 Stability Analysis Investigate dynamic and structural stability of the synthesised system. Use mechanisms implicit to models where possible. Examine convergence with P1.3.

P3.4 Outcome Evaluations Validate model: examine the selected model output and compare this to actual events. In relatively hard situations this may well involve a quantitative approach, and in the case of there being numerical outputs these must be interpreted qualitatively. A soft approach requires checking that the progress of the experience is appropriate. A match between model outputs and acceptable or real world events will indicate the level of ability of the modelling approach. Thus, relate model outcomes to phase P1.3. If convergence occurs, identify impact of modelling process by scenario adaptation in phases P1.1, P1.2, P1.4. Otherwise return to P3.1.

This phase distinguishes the ability of each model to represent the situation and the constraints under which it operates. Validation of a model only occurs if the modelling option evaluation has been successful.

4. Modelling Decision Options

The modelling cycle requires a full systemic evaluation of the conflict domain satisfying each phase of the Conflict Modelling Cycle. In Analysis, the problem environment is very strictly viewed as a *system* which is formally defined in terms of the appropriate theory; thus the constituent elements of the problem environment are defined, including who the participating players are, their attributes, functions, and relationships. It defines the framework of the situation being studied for each player: that is, identification of the nature of a player and its boundaries and influences. This is equivalent to defining the framework of perception of players, and very closely relates to the propositions that determine the way in which they operate.

Correctly, data should be collected from all players within the defined system and differentiation should be made between observations and player perceptions in order to address the next phase.

In the second phase, Synthesis, a formal set of propositions are synthesised which relate to the analysis of the conflictual system. For instance how far can one assume player rationality and within what contexts. The propositional base may include, for instance, consideration of under what conditions players will act against their rationally established preferences.

This can be followed by the creation of a set of decision tables. Each decision table will consist of three connected sub-tables: (a) properties, (b) objectives, and (c) goals [Yolles, 1992]. In the context of social conflicts, properties form the current characteristics of a player, and relate to its power base over each of the social, economic, political, and cultural domains. Goals represent that which each player intends to achieve in the long term. Objectives are the set of decision options available to the players which normally relate to their rationally established preferences. As a result of Decision table analysis, feasible solution can be found for the problem under consideration.

Feasible solutions are those which are logically consistent. *Feasible ORS* are those ORS states which can logically exist, and are determined from the set of system properties. The set of feasible ORSs in an n-player system compose possible *scenarios* of interaction for examination within a decision making framework. Thus, each scenario becomes a feasible decision making solution of the problem environment. A decision table would be created for each of 4 dimensions of concern in the above example, that is political, social, economic and cultural [Kemp, Yolles, 1992]. Scenarios are established within these tables. A scenario may be a one player identity of ORS that is feasible under defined conditions. These conditions are defined in the first part of the table. A scenario may also represent interaction when at least two players (e.g. an ethnic groups and a host player, or two coincident cultural minority groups) defining a set of states in contraposition to each other across each of the 4 domains. In this case the scenario also represents a set of mutual positions taken by each player on each state in the interaction.

5. Developing a Conflict Tableau

In consultation with a colleague G.Kemp, it was found that the decision table approach can be developed further as a modelling tool in its own right within the conflict modelling cycle. Here, objectives from each player have been assembled in order to form a conflict tableau which can be formulated into a set of feasible interactive scenarios (see fig. 2 and 3).

We may choose ${}^{r}S_p$ to represent the rth decision table of player p, and ${}^{r}s_m$ to represent the combined objectives tables for all of the players at the rth iteration at the m stable decision options. We can now define a futures trajectory which may occur along any branch of the futures tree.

The future scenario set ${}^{r}s_j$ for the rth iteration for the jth scenario is generated by inspection through the initial use of the methodology described below.

Initially the ${}^{r}S_p$ decision tables for r=0 are generated within the modelling cycle, and a tableau ${}^{r}s_j$ with j scenario possibilities is created. This tableau enables an interactive evaluation of the conflict domain to be attempted. Once this has been pruned, an investigation of how selection can effect the ${}^{1}S_p$ decision tables will be examined within the modelling cycle. It may be that there is no difference between ${}^{0}S_p$ and ${}^{1}S_p$, when a new futures set ${}^{1}s_j$ is generated directly.

Consider each objective table as a possible outcome of a decision option. A number of different outcomes can develop which are presented within a conflict tableau. Each of these possible outcomes is as a scenario. For an example of this see [Yolles, 1992a].

6. Choosing a Model

The third phase of the modelling cycle is that of Choice, where the modelling approach is chosen to solve the perceived problem. Two of the features of the approach adopted within this proposal are:
1) use the goals table for examining dynamic stability during iteration within the modelling cycle;
2) use the objectives table within a conflict tableau to examine the structural stability of the system under examination.

The identification of a stable set of ORS reduces the size of the conflict tableau. This reduced set can be used to evaluate the impact of each optional scenario on the original properties table to create a set of possible futures as shown in fig. 2. This in turn enables a dynamic stability evaluation to occur on possible futures.

The need to examine the conflict tableau to investigate the structural stability of the conflict environment requires the use of a methodology, the propositional basis of which conforms to that determined for the system overall. Examples of some of the methodologies that might be appropriate are in particular Conflict Analysis [Fraser, Hipel, 1984], or a variation on Saaty's multivariate decision analysis approach (called Analytic Hierarchy Process [Zahedi, 1986]), or simply expert evaluation.

After identifying the propositional requirements of the methodologies being considered, it may be appropriate to re-examine the overall system within the Analysis phase, reconsidering the player frameworks; this can enable the problem to be differently defined, i.e. whether a difference between expressed and perceived objectives should be identified, or whether the very nature of a given player or player set should be redefined. New propositions may thus develop, and decision tables already determined may in consequence be redefined; thus new objectives tables and a new conflict tableau may develop. In terms of game theory this relates to a redefinition of the game that each player is playing, and even whether it is the same perceived game.

7. Finding Stable ORS

Once a conflict tableau has been generated, it is appropriate to reduce the model to a set of feasible ORSs that are structurally stable. This may occur through human inspection, or through expert system inspection, or by the use of one of the multivariate decision analysis methods (e.g. Zahedi, 1986). It could also, for instance, be accomplished using the method known as Conflict Analysis [Fraser & Hipel, 1984]. This approach provides a useful introduction to the logical qualitative aspects which may be associated with scenario formulation within environments under change and in which there are potentially confrontational components.

A tableau may be generated to represent the objective set of feasible scenarios possible to each conflict situation. Players normally have distinct preferences and biases, and under this condition there will be a distinct and different preference ordering of scenarios which should be considered when undertaking a stability analysis.

The modelling approach can be extended by making a second circuit of the Choices phase; this can occur by making the conflict tableau the determinant for establishing a set of futures, since feasible objectives within the ORS will impact the properties and goals of each player to a degree which may or may not be discernable (fig. 3). Other circuits of the Choices phase might also occur perhaps prior to this.

Throughout the outcome evaluation and systems analysis, the futures can also be examined against the goals table which can contribute to an investigation of possible divergence, and thus dynamic stability. It should be realised that the selection of scenarios within one iteration represents the investigation of structural stability. The outcome of the iteration will be a redefinition of the propositional synthesis, and the creation of new decision tables.

The methodology is intended to be sufficiently robust to enable the changing environment within the domain of conflict to be satisfactorily represented through examining possible futures. A futures tree of new decision tables models is then created with as many branches as there are possible futures. These futures are then re-analysed in a continued iteration of the full cycle creating a set of possible future trajectories which will best suite the players both individually and interactively. As real events progress within the domain of conflict, the inappropriate branches are shed. Since a branch is a discrete component of a trajectory, inappropriate trajectories are thus also shed.

The evaluation of whether certain scenarios represent stable as well as feasible outcomes is determined by the use of the decimal values generated by each scenario as already explained in the previous section. These are flags which enable a logical investigation of the stable situation to be made according to an algorithmic process, rather than by forced logic alone. Certain scenarios are termed UI's (Unilateral Improvement) enabling a the state conditions of the environment for that player. A computer program is available to generate solutions to certain classes of problem. The whole approach is particularly suitable for computer simulation, since futures can be modelled examined, and evaluated more easily.

8. Simulation and the Modelling Cycle

This section of the paper is concerned with some of architectural needs that should be considered when designing a simulation system capable of helping modellers use the conflict modelling cycle to structure a modelling process.

In order to establish the modelling cycle within a computer system it is essential to take into account a number of aspects. These include the use of a decision aid to assist in determining the suitability of a modelling approach or technique; applying the concepts of knowledge based systems to guide the modelling process; and monitoring the system to identify where the modelling process is in the modelling cycle, its general progress and conceptual suitability, and how the modelling processes compares with reality.

8.1 Modelling Decision Support

In order to apply computer techniques to the conflict modelling cycle, it is appropriate to discuss the needs of a computer system to enable it to be able to determine what model to select, and how to do so. A Modelling Decision Support System (MDSS) can be thought of to consist of three subsystems, the Information Base subsystem, Database subsystem, and the Modelling subsystem. The three subsystems would be linked together by an interface block composed of: the DGMS - is a Dialogue Generation and Management System which enables the user to use the system in a user

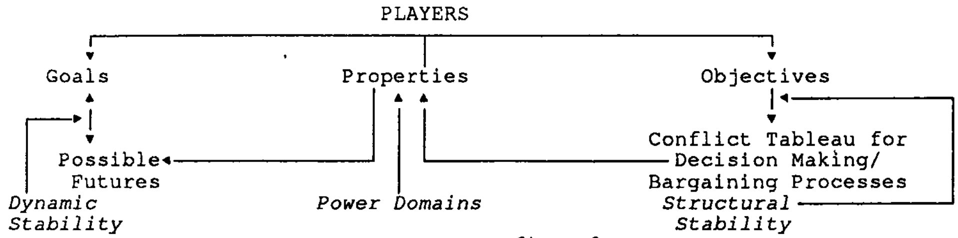
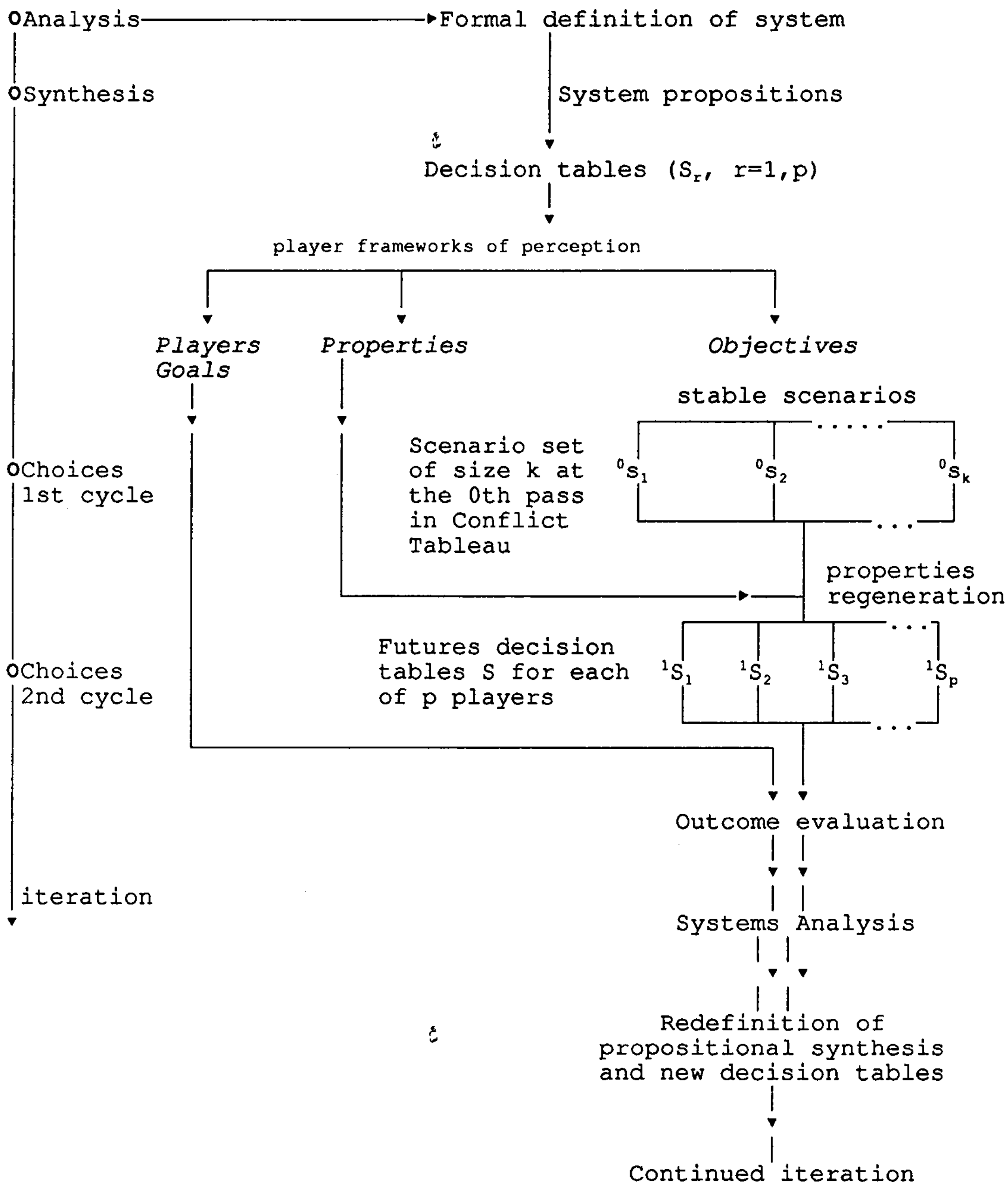


fig. 2
Relationship between Goals, Objectives, and Properties in the Decision Table Model



Note: $s_i = s_i(^1S_0, ^1S_1, \ldots, ^1S_p)$

Fig. 3
Futures Decision Table Analysis

oriented way; the SBMS - a Strategy Base Management System connected to a model base subsystem, which enable modelling strategies to be collected, offered to a modeller, and after a modelling selection has been made, applied; in an intelligent system, it will be able to assess the suitability of strategic models according to the characteristics of the modelling domain and the modeller; the MIMS - a Modelling Information Management System part of which is an Information Base Management System (IBMS), connected to the navigation process and generates an audit trail or history of the modelling process (through the database subsystem). Part of the MIMS is a monitoring system (MS) which enables implicit and explicit evaluation of the modelling process to occur.

Suitable modelling DSS environments may not only be able to chart a navigation process through its associated MIMS, it will also be able to guide the modeller through distinct levels of modelling process. In terms of management control, the MIMS can be described as having *strategic models* that will provide alternative strategies and processes of modelling, including media selection, *tactical models* will help the modeller navigate through a modelling domain, *operational models* will help modellers solve a current problem, for instance by directing them from a failed test result to a particular area of test. The subsystem can operate with data from the data subsystem to generate real time problem orientated models through the system interface. An extension of this is the explicit provision of a full monitoring and performance evaluation system with in-built advisor that activates the appropriate assistance required. This is system is shown in figure 4.

8.2 Other Consideration

Other considerations for the system relate to the use of deep reasoning methods for the evaluation of qualitative aspects of the system. The implementation of a modelling approach as identified within a metamodel has an implicit requirement to undertake qualitative reasoning. This requires a high level of intelligence which few systems have yet been able to introduce. The nature of deep modelling processes is basically qualitative. Some approaches are logically based, identifying appropriate requirements independent of local contexts. Others are rule based, using meta-rules to determine which surface rules of a set (with perhaps contradictory or competing elements) to select. Other approaches use mathematical methods, or a combination of all three. One approach in determining qualitative evaluations, according to Kuipers, has a history which goes back to the mid 1970's. The investigators of this area of study tend to focus on descriptions of the deep mechanism, capable of representing incomplete knowledge of a structure and behaviour within a process.

A final consideration that shall be made here is that of monitoring. The monitoring of a modelling progress through a particular modelling processes must be an implicit feature of a modelling system. The decision rules are determined by identifying the criteria necessary for making a decision. In a metamodelling environment they are typically determined from the experience of recurrent processes. When monitoring suggests that a modeller has not been successful is modelling a process, then feedback to the system decision maker is required in order that a decision rule relating to the current modeller can be adjusted or a new one introduced. A monitoring system is depicted in fig. 5.

9. Conclusion

This paper began by discussing metamodelling, thus the provision of a structured modelling approach. It examines conflict processes in a systematic way by initially defining a generic metamodel, and thus offering a modelling cycle involving the phases of analysis, synthesis, and choice, and relating model outcomes to the system under change. It is essential that a structured approach is adopted when modelling processes. In particular, individual approaches and mathematical formulations become more meaningful if they are presented in logical association within a modelling cycle.

One approach in modelling conflict was to define decision tables relating to a conflict that had been properly examined and defined according to a set of criteria. After defining the propositional base for the conflict, decision tables are created involving player goals, properties, and objectives. The objectives become the interactive component of the decision tables when combined together in a Conflict tableau. The tableau is pruned to a set of stable scenarios.

In the next phase of the cycle, the stable scenarios lead to possible futures for the conflict which may be constructed by a variety of methods, applying either soft or hard methods. Soft methods in the context of social conflicts may require discussion with participants combined with table inspection, or expert system approaches can be adopted. Alternatively,harder approaches can be used, for example through the estimation of probabilities in Markov Processes.

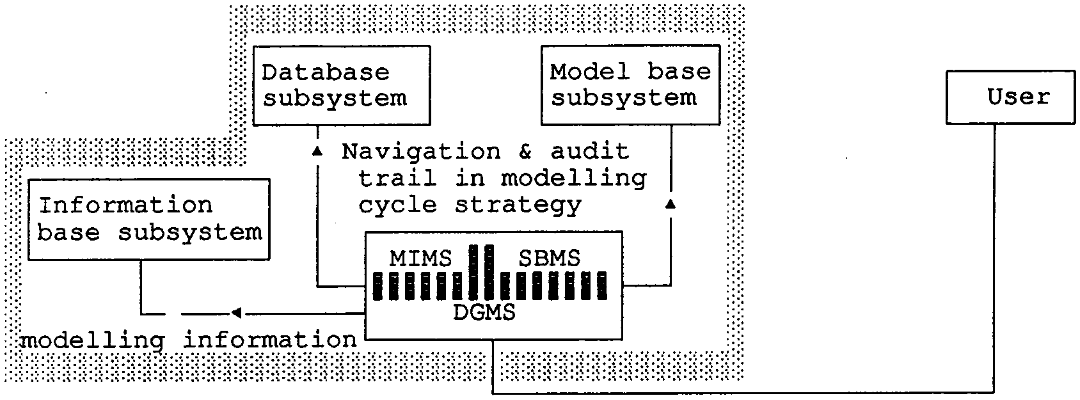


Fig. 4
Relationship between MDSS Subsystems

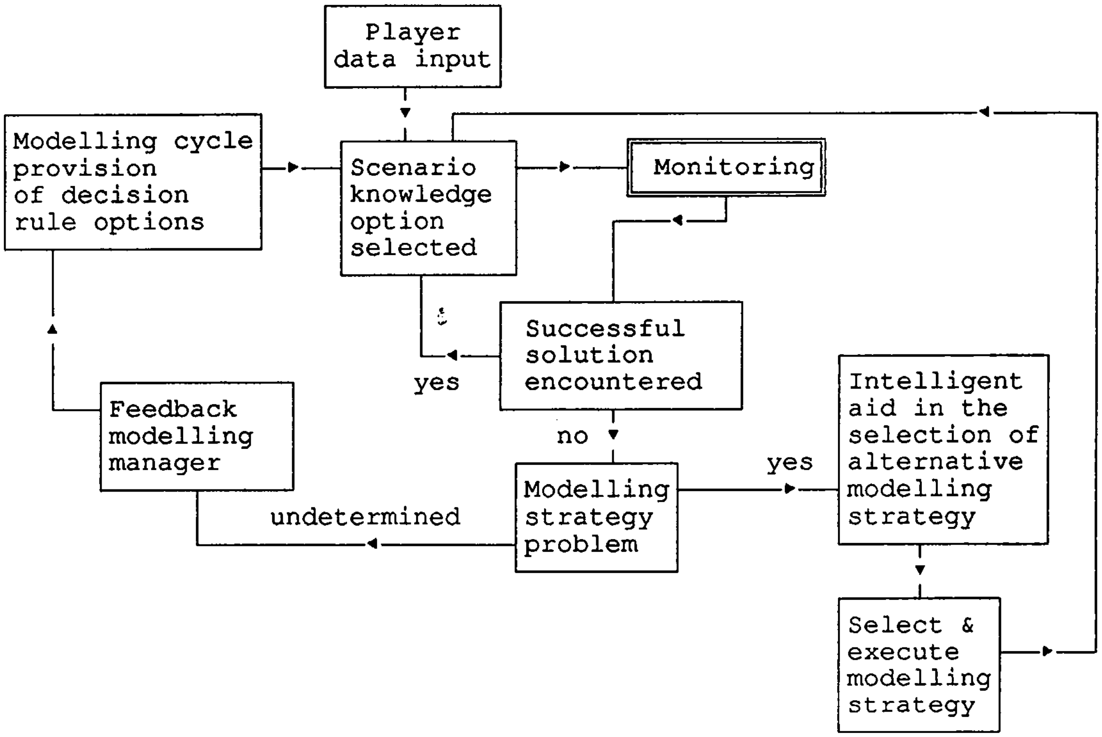


Fig. 5
Modelling system monitor for determining if a selection of another modelling strategy is required

The result of this choices modelling approach then feeds back into the analysis phase before iteration occurs again, in order to generate a further phase or set of phases within the process. By establishing the linkage between the methodologies the modelling cycle has been shown to have a continuity in the way that these models can be applied to real situations.

Finally, some consideration has been made on how such a modelling process might be established within a computer based system. This rests upon the development of a decision support system with an implicit intelligent knowledge based system able to monitor and examine the modelling process as represented within the modelling cycle.

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