

# Hard OR, Soft OR, Problem Structuring Methods, Critical Systems Thinking: A Primer

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## Abstract

Up until the early 1970s there was a fair consensus among operations researchers and management scientists of what MS/OR meant, i.e., the application of quantitative methods to model decision making situations in view of achieving some well-defined objective within a systems framework. Optimization of some performance measure was usually an integral part of the methodology. This all changed in the 70s, 80s and 90s with the development of alternative approaches to decision making and problem solving. The methods and methodologies expanded systems thinking to a more diverse and wider range of problem situations, which put greater emphasis on the inherent human aspects and where the concept of optimization largely lost its meaning. These methods also claim to belong to MS/OR. This paper gives an elementary overview of this development, classifying the approaches, and highlighting their major features. The discussion is highly influenced by M. C. Jackson's *Systems Approaches to Management* [5].

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## 1 Problem Situation Context

Jackson and Keys [3] classify problem situations along two dimensions: *complexity* and *divergence of values and interests*. Complexity is understood as the number of elements and their interactions. Few elements and well-defined, linear, stationary interactions imply low complexity; many elements, many interrelationships, dynamic and not well-understood relationships in a turbulent environment imply high complexity. They divide divergence of views into *unitary*, *pluralistic*, and *conflicting/coercive*, where unitary implies agreement of views of the stakeholders involved, pluralist implies multiple views within a shared common core, and conflicting/coercive implies irreconcilable views and differences in the power relationships between stakeholders.

For our purposes it is useful to differentiate between two types of complexities: *technical complexity* associated with the physical, mathematical, or computational nature of the problem and *human/social complexity* associated with the interrelationships between the stakeholders.

These three dimensions can be used to classify the three main streams of MS/OR approaches, as depicted in the Figure 1 below.

**Functionalist systems approaches** assume that systems are 'objective' aspects of reality, largely independent of the observer, i.e., different observers would basically see the same system and share the same goals or objectives. Note that this does not imply that different observers and modellers may not draw the system boundaries differently or select a different degree of resolution to model the system. Functionalist approaches have seen successful

applications in problem situations that may have considerable technical complexity, but in general can only cope with low human complexity and low to medium divergence of interests (i.e. multiple objectives, in contrast to values).

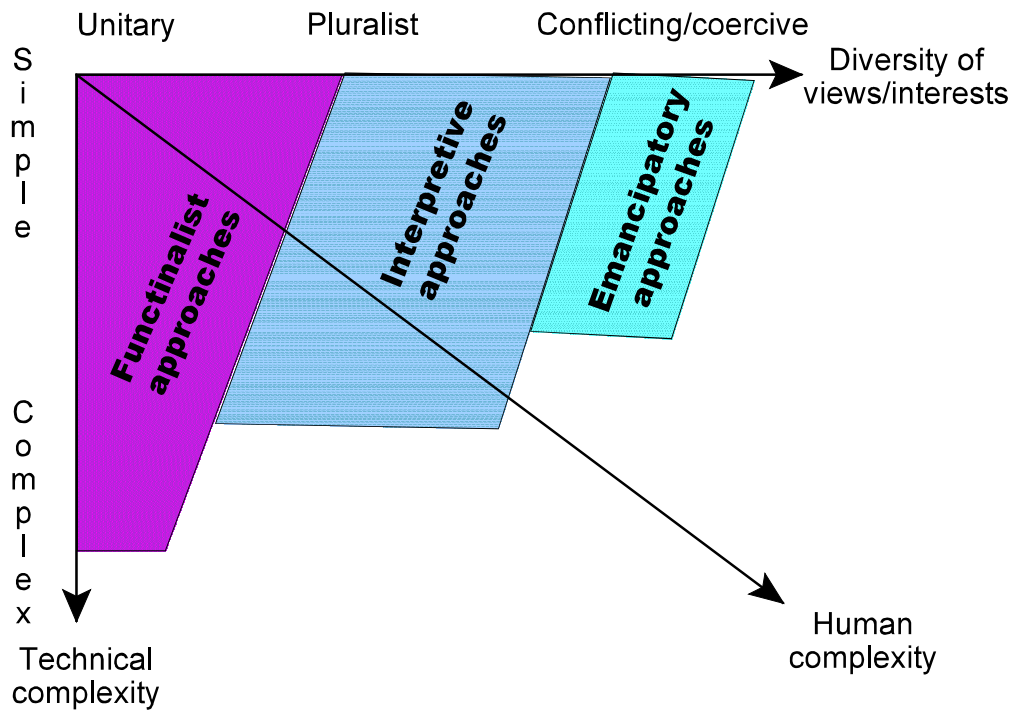


Figure 1: Problem situation classification and systems approaches (adapted from Jackson [5])

**Interpretive systems approaches** adopt a subjectivist approach to systems thinking. The system defined for a given problem situation reflects the observer's *world view* (i.e., the coloured glasses used to interpret the world, based on her or his social and cultural background, education, experience, and personal values). It is not assumed to exist in exactly this form in reality, but is seen as a personal conceptualization of what the observer views as a useful and convenient representation of interrelationships in view of learning more about the behaviour of the system. Although interpretive approaches allow a certain divergence of interests and views, they assume there is a sufficient sharing of interests that the various stakeholders consider it in their interest to cooperate. Interpretative approaches can cope with a fair degree of human complexity and diversity of interests and values, but have greater difficulty to deal with technical complexity.

**Emancipatory systems approaches** also take a subjectivist view of systems. However, the various stakeholders may see radically different relevant systems with different values and *boundary judgments* (i.e., justifications of what is relevant and what is not), and they may be in a conflicting or confrontational relationship with each other and possibly unequal in terms of their *power* over the situation, with some being potentially in a victim role. These approaches have difficulties to cope with both high technical and human complexity. 'Resolutions' of such problem situations may involve reforms and changes in the current social order. Their domain of application is mainly in public policy issues.

## 2 Functionalist Systems Methodologies

Functionalist system methodologies include

- **traditional MS/OR,**
- RAND type **systems analysis** (1955),
- **systems engineering,**
- **system dynamics** (1956),
- organizational cybernetics, such as **Stafford Beer's Viable Systems Model** (1959),
- **complexity theory** (1963), and other approaches that are at the fringe of MS/OR.

The first four are also collectively known as **hard systems approaches** or **hard OR**.

In general, these approaches are based on the following assumptions about the problem situation:

- the problem has been clearly defined, the objectives of the decision maker(s) are known and there exist criteria to ascertain when they have been achieved; the alternative courses of action are specified, either as a list of options or sets of decision variables; the constraints on the decision choices are known; and all input data needed are available;
- the problem is relatively well structured, meaning that the relationships between the variables are tractable; they can be expressed in quantitative form; and the computational effort for determining the optimal solution is economically feasible;
- the problem can be sufficiently well insulated from its wider system of interest;
- the problem is of a technical nature, largely devoid of human aspects; and
- the decision maker can enforce implementation of the solution.

With the exception of the Viable Systems Model, these approaches involve the use of quantitative approaches in the form of spreadsheets, computer simulations, statistical analysis, or potentially large mathematical models and optimization techniques. They have been successful to deal with highly complex physical systemic relationships. In today's world, few human activities in all walks of life are not touched in one way or another by the results of projects involving hard OR.

## 3 Interpretive Systems Methodologies

Interpretive systems approaches — also known as **soft systems approaches** or **soft OR** — address problem situations which are messy, ill-structured, and ill-defined in terms of their human components and relationships, not independent of the people involved, in other words, where different stakeholders with different world views have different, possibly conflicting perceptions about the problem situation and its major issues; where there may be no agreement about the appropriate objectives, or even the set of possible actions; and where it may be meaningless to talk about optimization, since a resolution usually involves a compromise, but where there are sufficiently shared values and interests to cooperate. They are characterized by

- structuring the problem situation, rather than by problem solving;
- facilitating dialogue between the various stakeholders with the aim of achieving a greater degree of shared perceptions of the problem situation, rather than providing a decision aid to the decision maker;
- 'What' questions, more than by 'How' questions, i.e.,
  - 'what is the nature of the issue?';
  - 'what are appropriate objectives?' given the various world views of the stakeholders;
  - 'what is the appropriate definition of the system for the issue considered?'
  - 'which changes are systemically desirable and culturally feasible?'

and only then

‘how are these changes best brought about?’

- eliciting the resolution of the problem through debate and negotiation between the stakeholders, rather than from the analyst; and
- changing the role of the ‘problem analyst’ to one of becoming a facilitator and resource person who relies on the technical subject expertise of the stakeholders.

Note that ‘how’ questions, i.e., which means are the best for achieving the desired objectives, must ultimately also be addressed by soft systems methodologies. But they are often an anti-climax, almost obvious, rather than being centre-stage as in most hard OR projects. ‘How’ questions may give rise to separate hard OR projects within a soft OR approach.

Given the emphasis on problem structuring, J. Rosenhead coined the label **problem structuring methods** in his text *Rational Analysis for a Problematic World* [8].

Methods include **hypergame analysis** (1980), **metagame analysis** (1960s), **interactive management** (1974), **operational gaming** (1950s & 60s), **robustness analysis** (1980), **soft systems methodology** (1975), **strategic assumption surfacing and testing** (1969/81), **strategic choice approach** (1969), **strategic options development and analysis** (1979), **drama theory** (1990/93), and the most recent addition, the **theory of constraints** (1994).

The majority of these approaches were developed through action research and/or consulting practice. Some, such as Checkland’s soft systems methodology, are firmly based on systems thinking and systems concepts. Several methods originate in the ideas of game theory, but abandon its rigorous axiomatic foundations and only retain its outer form, i.e., two or more players with opposing views. Some approaches, such as cognitive mapping (as part of the strategic option development analysis or SODA) have subjectivist psychological roots. The majority use *ad hoc* processes that have evolved through consulting practice and/or action research and have proven successful for certain situations.

They all have one thing in common. They start out seeking to attain a reasonably comprehensive view of the issue(s) within its wider context, although most recognize that true comprehensiveness is impossible, nor may it be needed to get to a workable resolution of the ‘problem(s)’. This initial analysis is then structured in various ways, e.g., by uncovering uncertainties about values, choices, and the environment, and identifying clusters of highly connected aspects. The main aim at this stage is to gain a shared understanding and mutual appreciation of the issues, including personal world views and objectives. The aim is not necessarily to bring about a convergence of views, but in practice at least a partial convergence is likely to emerge from this process. The ultimate aim is to get a commitment for action. Most approaches iterate through or between various modes of working. Several methods use specialized software to aid in the structuring process and/or the exploration of the combination of choices available. Most require a facilitator, with sufficient training and experience in the method and with good interpersonal and negotiation skills.

It is fair to say that so far, the use of these methods comes predominantly from the developer(s) (often within a consulting practice) and a small group of acolytes, many of whom are academics. Few users are sufficiently familiar with more than one, although this is slowly changing with several universities offering courses in problem structuring methods.

## 4 Emancipatory Systems Approaches

Emancipatory systems approaches sit somewhat uncomfortably in the overlap between sociology, organization theory, systems thinking and by extension management science. These approaches claim that functionalist and interpretive systems approaches tend to accept existing inequalities of wealth, status, power, authority, gender, race, and sexual orientation, and largely neglect those

views and interests of those who have no voice in the decision making process, but who suffer the consequences, including future generations, non-human species, and the environment. In this way they serve to support, buttress and legitimize the status quo. Emancipatory systems approaches aim to identify such inequalities and neglect and promote radical change to emancipate and liberate the deprived majority and create a civil society. Much of the work in community OR has been along that nature. They are seen essential to deal effectively and equitably with issues, such as poverty, health care, and the environment, etc.

In contrast the functionalist and interpretive approaches, emancipatory systems thinking has remained largely on a philosophical and polemic level. The exception is Ulrich's Critical Systems Heuristics [10], which (in his words [1]) provides a systematic philosophical foundation and a practical framework for the kind of *critical systems thinking* needed to create a civil society. Since any systems analysis can never be completely comprehensive and furthermore is affected by the personal world views of the stakeholders with the power of decision making, critical systems heuristics provides a methodology for systematic critique for boundary judgments that are and need to be made for sound professional practice, whatever importance may be attached to emancipatory issues.

## 5 Critical Systems Thinking and Multimethodology

Critical systems thinking has its first roots in the early 1980s in the work by Jackson, Mingers, and Ulrich, resulting in a critical awareness of the short-comings of various hard and soft systems approaches, and it emerged as a new integrative systems perspectives in the late 1980s and early 1990s. Its aims are to foster systemic debate on social ends and power relationships, as well as on the relationships and complementarity between various systems approaches and their underlying paradigms in view of assessing their suitability for various problem situation characteristics and guide their use. The latter has led to the recognition of *methodological pluralism* [3] [4], i.e., that by a critical awareness of the strengths and weaknesses of different methods and methodologies the most appropriate ones can be chosen to address (individually or in parallel) a wider range of problem issues than a single method can, or the idea of *multimethodology* [6] [7], i.e., that various methods and methodologies are used in combination for different aspects of an intervention or aspects of one can be borrowed and incorporated into another for more effective results. *Boundary critique*, along Ulrich's critical systems heuristics [10], is seen as the necessary front-end for all interventions in order assess and manage conflicts of values and interests and power relationships.

Critical systems thinking is not a methodology. However, some attempts have been made to operationalize some of its ideas. The most prominent of these is Flood and Jackson's **Total Systems Intervention** [2], which they describe as a *meta-methodology* for guiding the practice of systems interventions within a critical systems thinking framework. It consists of three phases. The *creativity* phase identifies the dominant and dependent issues using various systems metaphors (viewing the organization as a machine, an organism, a brain, a culture, a political and a coercive system). The *choice* phase identifies a main system-based methodology for the dominant issue, with other methodologies as support, which are then used in the *implementation* phase to bring about change. Unfortunately, the recipe remains rather vague and puts high demands on the analyst in terms of thorough expertise in the various methodologies.

## 6 Concluding Remarks

Since the 1970s, MS/OR has expanded from its originally quantitative systems focus in various directions that encroach on or straddle other disciplines, such as critical philosophy, social and

human behaviour fields, and areas traditionally seen as business administration, such as organizational behaviour and strategic management. This blurring of boundaries can be seen as part of the ever greater awareness of the interdependence of disciplines, and the complexity of today's world and of its systemic relationships that do not respect discipline boundaries, and last but not least the search for equity.

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