
A Taxonomy of Current Approaches to Systems Analysis

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In the last few years a number of systems analysis approaches and methodologies have arisen. There is confusion in the choice of using these approaches and in this paper the authors argue that methodologies are in fact different perceptions in the field of systems analysis. Each methodology is discussed and classified in terms of paradigms, conceptual models and objectives.

INTRODUCTION

The discipline of systems analysis is still very young and in common with most other emerging disciplines it occasionally enters periods of radical self examination and re-thinking. The authors feel that we are in the midst of such a phase at present; new ideas abound, arguments rage, and the development of technology is a powerful impetus to the re-examination of ideas.

The reason for the current turmoil in systems analysis is the emergence over the past few years of a number of new approaches or methodologies.¹ These approaches have generally originated as academic ideas and been taken up and modified in the practising world of systems analysis. Thus there exists a confusing array of approaches. It is the purpose of this paper to examine some of the more fundamental approaches and to attempt to classify them. It is the authors' view that the approaches are not simple alternatives, but that they seek to do different things.

The authors have identified six major approaches to systems analysis: (i) General Systems Theory Approach; (ii) Human Activity Systems Approach; (iii) Participative (Socio technical) Approach; (iv) Traditional (NCC, etc.) Approach; (v) Data Analysis Approach; (vi) Structured Systems (Functional) Approach. Except for the General Systems Theory Approach they are all used to some extent in the industry today. General Systems Theory is included as an approach because of its important influence on systems thinking in general and because of the contribution it has made to almost all the other identified approaches.

GENERAL SYSTEMS THEORY APPROACH

General systems theory (GST) deriving from the work of L. von Bertalanffy has had much influence,² but has not really been concerned with practical systems analysis. It is more an attempt to come to terms with and understand the nature of systems. It is theoretical model building for the interpretation of complex and diverse systems.

Since the identification and propounding of GST many people have tried to apply the theory to the solving of practical problems.³ This attempt has been notably unsuccessful.^{4,5} The reason for this lack of success is that the very generality of GST makes it difficult to use and to develop a methodological solution; and where a solution is arrived at it is often one which requires a revolution to implement. It is not a process which often recommends small incremental changes but one which more usually results in the complete reassessment of structures, roles and behaviour. Indeed it has been called by Popper, Utopian Engineering, i.e. implying redesign of the whole fabric of society.⁶ This may well be overstating the case but it is certainly unlikely to be an approach to appeal to the systems analyst who has an inbuilt leaning to the pragmatic. A systems analyst who recommends giving the product away free as a revolutionary solution to the problem of invoicing the customers would probably not last long in his chosen profession. Although he may argue that his is the correct solution from society's point of view.

Thus the systems analyst considers the application of GST too impractical and wide ranging for his purposes, after all he has terms of reference within which he must work!

The counter argument is of course that these restrictions impose conditions on the systems analyst which are the very reason why he is actually not very successful in his problem solving. He can only tune the engine when perhaps what is needed is the redesign of the transport system.

A number of people have sought to come to terms with this problem and make GST more practical for problem solving. They have striven to convert GST into a practical methodology by firstly, breaking down the process into a number of defined steps to be followed and secondly, seeking to limit the range of alternative solutions by introducing notions such as the identification of certain value systems within which the problems must be set.

Perhaps the best known of these attempts is Checkland's Methodology for real world problem solving which here we classify as the Human Activity Systems Approach.⁷

HUMAN ACTIVITY SYSTEMS APPROACH

Checkland has tackled some of these problems in the design of his methodology. First he attempts to provide a methodology for solving problems which are not precise or of well defined structure. He argues that these are the sort of problems that need to be dealt with in the environment or organizations and management; they are what is known as fuzzy or soft problems. Second he seeks a solution to the problem which he acknowledges is only one of perhaps many possible alternative solutions. This makes the methodology very much more practical for it is often found in reality to be very difficult to define objectives and usually very contentious to try.

It is not the purpose of this paper to describe the methodology but simply to categorize it. Checkland has developed a methodology based on the notions of GST but modified in some significant ways to be practical in the real world, and it has been used in many cases with evident success.⁸ The methodology can be categorized as GST approach, with emphasis on unstructured problems in complex situations. It generates understanding of the environment and leads to possible structural, procedural, attitudinal or environmental change that will improve the situation. The change is then implemented. This of course is the crux of the situation because it is here that the work of the Systems Analyst normally starts and yet this is the point at which Checkland's methodology is least concerned. The philosophy behind Checkland's methodology is that analysis and understanding of the situation and environment within which the problem lies leads to a possible solution.

This approach to systems analysis is therefore not in competition with most other approaches, and indeed could be regarded as complementary to them. It tries to explore, identify and structure the problem before 'solving' it.

THE PARTICIPATIVE APPROACH

This approach is most commonly associated with Mumford, Land and Hawgood and stresses the importance of the user in systems analysis.⁹ Many other people have of course argued the importance of people and the human element in systems but Mumford takes this a step further and argues that the users ought to be involved in the design of a system in which they participate or preferably actually design it themselves. This approach seems to have generated a lot of interest recently. Possibly because it directs itself to a very practical problem: that of the rejection of the system by the people who use it, or if not outright rejection then much reluctance and slowness in accepting the new system. Such factors have often been found to handicap a system fatally. An extreme example is the rejection of new technology in Fleet Street. Clearly it is not a revolutionary approach; it does not seek ways of finding radically new solutions to business problems. It is a way of making sure the implementation stage of a project is acceptable to the users by letting them design the user/machine interface. It is revolutionary only in the idea that it should be the users who do the designing. Every Systems Analyst will say that he already takes account of the users' wishes, but

the question is to what extent this is done. Even in Mumford's scheme the users design only within the constraint of the assumption that a computer is to be used in the solution.¹⁰ What the user may design is the work situation into which the computer is to be brought and he helps to determine how the man/machine interface is organized. The authors do not criticize this approach, indeed it seems to be a beneficial and praiseworthy method. However, one should be clear that it is not a systems solving methodology. It is an attempt to achieve smooth implementation of a system, and successful operation of the computer in the workplace. A comparison with Checkland's system reveals that it is not problem solving at the same level. It is concerned with solving implementation problems.

THE TRADITIONAL APPROACH

Perhaps the most common approach to Systems Analysis is that advocated by the National Computer Centre (NCC), often termed the traditional approach.¹¹ In some form or other, this is the approach adopted by the majority of systems analysts. It contains the well known phases of investigation, analysis, design and implementation. It is an approach based on the idea that there exists a problem which can be solved by the application of a computer. Each application is considered separately and the problem resolved by the design of an optimal subsystem. The optimization is achieved by investigation of the existing system in terms of the functions that it performs. The analysis is the distillation of the results of investigation into a documented form and design is achieved by consideration of the required outputs and designing the inputs, files and processes to achieve those outputs. A tried and trusted formula, the result of which has been the piecemeal computerization of manual subsystems. What has usually not been solved is the problem that led to the demand for the introduction of a computer in the first place. At best, time has been bought by making the manual system more efficient. This has been fine for particular circumstances, for example payroll, invoicing and billing. Where it has proved inadequate is in more complex areas, such as accounting systems or information systems.

DATA ANALYSIS APPROACH

The developing methodology of data analysis is based on the philosophy that the fundamental building blocks of a system are data.¹² The hypothesis is that if we can classify and identify the set of data elements (entities and attributes) that exists within a particular situation then we have identified the true nature of a system. The use to which that particular system can be put can change or be changed, but the underlying nature of the system remains unchanged because the data is static, or much less likely to change than the function or processes applied to it. This means that one can define the system without defining the individual applications that need to use it—obviously a very useful concept. In addition if relationships between the data are defined then one has, in effect, developed a model for the system which can be validated before implementation. Data analysis can be seen, therefore, as a 'neutral' way to come to an agreed

understanding about the nature of an organization. It fits in very nicely with (indeed it has developed from) the concept of the data base. We seek to map the system as it exists and then later solve our problems easily by functional applications on the data base.¹³ Data analysis however is not orientated to problem solving in itself. What it seeks to do is clearly to define the basis, in terms of data and relations of the system in which the problem exists. Ideally it seeks to do this on a company or organization-wide basis. A clear mapping and understanding of the way an organization works is indeed very useful. If the mapping or logical data model forms the basis of all the subsequent applications the worry is that this base will in time prove inadequate because its source was the existing system. Data analysis concentrates on the investigation and analysis phases of Systems Analysis and says very little about system design or problem solving. Yet the inference is that successful data analysis leads to successful design. We need to question this. Data analysis may not solve underlying problems that the organization might have. Indeed it may have 'captured' the existing problems into the new data model, and made them even more difficult to solve in the future.

This is not to say that data analysis is not a powerful tool to help in clarification, understanding and communication, but that it is not necessarily going to provide a solution to a business problem.

STRUCTURED SYSTEMS ANALYSIS APPROACH

Structured Systems Analysis is described perhaps most eloquently by de Marco¹⁴ and Gane and Sarsons.¹⁵ It appears that this approach or method is one that is beginning to be used in an increasing number of organizations. It is an attempt to solve some of the problems of the traditional approach, such as the departmental/subsystem viewpoint, the problems of coordinating a large team of analysts, and the problem of complexity of a large organization or system. The approach provides new tools for analysis and documentation, such as data flow diagrams, the concepts of data dictionaries and structured English. The use of these enables the clear documentation of existing systems and proposed new systems. It suggests methods of analysis but none for design. Indeed when de Marco comes to the design of the new system he states clearly that this is not one of his aims. He says 'It is at this time that the Systems Analyst exercises his experience and imagination to come up with new systems concepts. This is where he 'invents' the new system. I won't tell you how to go about this—I have restricted myself to teaching new tools for analysis, and no tool that I could think of would aid the invention process, when you have come up with your invention, however, the tools of Structured Analysis are exceedingly useful for documenting it and trying it out.'

It is this aspect that is often forgotten and it is often thought to be a design methodology.

CLASSIFICATION SCHEME

The preceding discussion perhaps serves to illustrate the complexity and diversity of the various identified ap-

proaches to systems analysis. This diversity is a reflection of the differing viewpoints embodied in the approaches. The differing viewpoints arise because it is so difficult to observe objectively a system that exists 'out there' in the real world. Our perceptions of that reality are different and subjective and it is these different perceptions that lead to the differing approaches. It is the authors' contention that the differing approaches can be better understood by an examination of the paradigms, conceptual models and their objectives, that the approaches are based upon.

PARADIGMS

First the authors feel that a major contribution to the understanding of the differing approaches can be achieved by examining the underlying paradigms on which the approaches are based. Paradigm is used here in the sense identified by Kuhn as a specific way of thinking about problems encompassing a set of achievements which are acknowledged as the foundation of further practice.¹⁶ A paradigm is usually regarded as subject free, in that it may apply to a number of problems regardless of their specific content.

The authors identified two basic paradigms to be of interest in this context, firstly the science paradigm and secondly the systems paradigm.

The science paradigm embodies the scientific method which has led to the development of the 'hard' sciences and without becoming ensnared in the controversies that surround discussions of the philosophy of science we opt for Checkland's description of the science paradigm as being a learning system characterized by reductionism, repeatability and refutation.¹⁷

'We reduce the complexity of the variety of the real world in experiments whose results are validated by their repeatability and we build knowledge by the refutation of hypotheses.'

The systems paradigm is not so easily condensed because there is no unique acceptance of what constitutes the systems paradigm. What is clear is that the origin of the systems paradigm derives from the concern of some that the science paradigm was proving inadequate when faced with living systems and particularly human activity systems. These systems exhibit openness, low separability and high interdependence. Such systems, if reduced in the method of the science paradigm, lose their meaning and the ability to be explained. This is so because such systems are more than the addition of their individual components because, as Checkland explains, the parts, when aggregated, display emergent properties. Thus the systems paradigm is a holistic one.

Let us now examine our six identified approaches in terms of the paradigms which they adopt. First, General Systems Theory is by its nature wholly based on the systems paradigm. Its interdisciplinary nature; its concern with value systems and objectives; its analysis of the interaction of subsystems; and its resulting advocacy of major structural and social change are clearly in the mainstream of the systems paradigm.

Checkland's approach also incorporates the systems paradigm, by his own admission, and by the concentration on open systems, fuzzy problems and purposeful activity. This, despite the fact that Checkland reduces

his area of concern from the global level to that of the organizational level, in order to make the methodology more practical in the real world.

The third approach incorporating the systems paradigm is the participative approach. Here it is the belief in the interaction of the social and the technical subsystems that leads to an advocacy of the participative design philosophy. The work system is analysed for variances or weaknesses which prevent the system objectives being realized. These variances are often discovered at subsystem boundaries, particularly where the social and technical subsystems meet. The ideas of job enrichment and participative design are particular solutions to the more common variances which are encountered. Thus the underlying paradigm for this approach is argued to be the systems one.

The traditional approach to systems analysis on the other hand we believe, embodies the science paradigm. This comes as a surprise in that it is usually thought to be based on the systems paradigm. The theory of the approach clearly adopts the systems aspect, but we argue that the practice clearly embodies more of the science paradigm. The approach is reductionist in that systems are broken down into their component subsystems and that these subsystems are then optimized and implemented. The approach rarely examines the overall system and its interactions, but simply takes a subsystem as it exists and converts it to a computerized form.

The data analysis approach would also seem to embody the science paradigm. Here the observations about the complex real world of organisations are reduced to the study of data. It is postulated that the data are the basic building blocks of the organization.

Key elements of data, described as entities and attributes with the relationships between entities, are identified. This data model serves to define the organization or subsystem of the organization, in a time and function independent way. The hypothesis is validated by the participants in the organization being able to define the functions they perform in terms of the data model. The systems paradigm is clearly rejected by the concentration on the single area of data and the ignoring of any notions of subsystems interacting with or on the data.

The structured approach also incorporates the science paradigm. It is concerned with breaking systems down into lower and lower levels until each component can be easily understood. It is also concerned with providing tools and techniques for this purpose. Thus it can be said to rely heavily on the scientific method.

CONCEPTUAL MODELS

Having examined the paradigms underlying the various approaches we now turn to the question of their conceptual models.

The conceptual model is defined as a subjective representation of reality which is implied in each methodology. To illustrate this definition, it is as if a number of different people have looked at a piece of land and set about drawing a map of it. The results all might be very different because of the differing choices made as to what is of importance. Thus one person might draw a map indicating the roads, another the contours, another

the geology and yet another the climate. Each map is a subjective representation of reality—the view, just as the conceptual model is implicit in each methodology and is the subjective representation of reality to the researcher or practitioner in constructing or using a methodology.

General systems theory is based on a model of the world which exhibits pure systems traits. Systems have objectives, they are composed of interacting subsystems which exhibit particular behavioural characteristics. The conceptual models help to achieve a better understanding of the system by identifying the interactions. These conceptual models are constructed from the following criteria: Abstraction—the mental resolution of the salient features of a systems structure; Congruence—identification of the problem situation and its solution; Eclecticism—the interdisciplinary nature of a model; Syncretism—the admission of different value systems. The latter is the most important criterion in structuring the conceptual models in the General Systems Theory approach.¹⁸

The Checkland Model is similar but does not include the notion of definitive objectives. The objectives of a system are by no means clearly or easily defined in Checkland's model. Differing participants may have conflicting objectives, thus Checkland avoids objectives in his model. He introduces the concept of soft or fuzzy systems in which the conceptual model is generated from the encapsulation of a system, based on the actors in the problem situation, the client of the system, the owner of the problem, the transformation process and the system environment.¹⁹

The participative approach has a totally different conceptual model, somewhat at variance with those already examined. These models are based primarily on people and their needs, and seek to find a 'fit' between the people and their needs and the work environment: the organization structure, technology (computers) and the work tasks.

The traditional approach to conceptual models is functional. The breakdown of the functions and the optimization of these subfunctions is the basis of the model. The goal is the optimal functioning of each individual subfunction which will produce an efficient and workable computer subsystem.

The manifestation of the model should be achieved in the anatomy of a computerized information system on the application processes, integrated files, file maintenance, recovery, control, monitoring and information retrieval.²⁰

In the data analysis approach, the conceptual model is clearly one of data: entities, attributes and relationships. Whereas in the structured systems approach, the emphasis is more on the functions rather than the data, although the functions are observed from the viewpoint of the data rather than the viewpoint of any person or organization. The use of these models concentrates on using tools and techniques on the real problem in communication within systems analysis.

OBJECTIVES

An examination of the objectives of each of our chosen approaches to systems analysis is illuminating. General Systems Theory, Data Analysis, and the structured

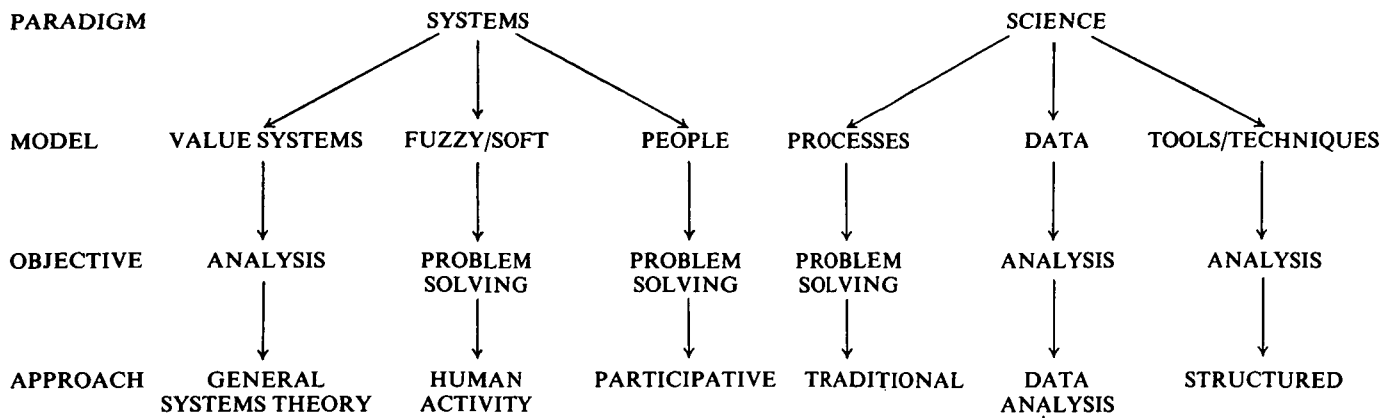


Figure 1. Taxonomy of systems analysis approaches.

approaches all seek to achieve a better analysis of a situation or an organization as their objective. This better understanding may lead to the solving of various problems that the organisation or the system may have, but these approaches do not actually seek to provide a method for solving them. The other approaches, namely Checkland, the participative and the traditional approach, all actually claim to be methods of problem solving and are attempting to achieve more than just the provision of a better understanding. The authors argue that this question of objectives is often ignored and leads to misunderstandings concerning the various approaches.

CONCLUSIONS

The authors have sought to describe the characteristics

of various approaches to systems analysis, as classified in Fig. 1. It has been argued that the approaches are diverse and perhaps should be understood in terms of the paradigms that they incorporate and the conceptual models and objectives they hold. Perhaps by identifying the differences in these areas the reader may view the approaches in a new light, and perhaps utilize the approach that meets his requirements. It may also serve to establish why the various approaches exist and perhaps enable them to function side by side.

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