Interactive decision support system for organisational analysis

Sushil
Indian Institute of Technology, Hauz Khas, New Delhi, India

B. Raghunathan
Indian Institute of Technology, Hauz Khas, New Delhi, India

Quantification of important soft variables which affect the functioning of organisations is crucial for organisational analysis. Initially, only two of the many variables have been taken for analysis. A software interactive model has been developed to facilitate the analysis of organisational problems with specific reference to authority and responsibility issues. The graph theoretic approach has been used to model authority-responsibility relationships existing in the organisation. In line with the postulates of Physical System Theory (PST), managers at various levels are conceptualised as multi-terminal components interacting between the superiors and subordinates. The unit authority across any two adjacent levels is different and hence taken as an "across variable", whereas the responsibility flows through the organisation and hence taken as "through variable". The software has been developed based on microprocessor (PC) environment, using one of the most popular software package DBASE III Plus so that analysts can effectively use this package. To start with, this software has taken into account the basic requirements of data base creation, editing, query facilities, and generation and solving of equations. This software may prove to be of great assistance in analysing the existing or projected inconsistencies in the authority-responsibility relationships.

Keywords: Organisational analysis; Authority; Responsibility; Physical System Theory; Software Package.

Dr. Sushil is Associate Professor with the Centre for Management Studies, IIT, Delhi, India. He has participated in conferences/Seminars at national and international levels. His research interests are Systems Analysis, Waste management and Industrial engineering. His papers have been published in the International Journal of Production Research, International Journal of Systems Science, Engg Costs and Production Economics, Systems Research, European Journal of Operational Research, etc. He has over 80 research papers to his credit and a book entitled Systems Approach to National Planning - A Study in Waste Management.

Correspondence to: Sushil, Centre for Management Studies, Indian Institute of Technology, Hauz Khas, New Delhi - 110016, India.

1. Introduction

1.1. Organisation and their structure

Organisations are for the people, by the people and of the people. In order to achieve some goals set by a group of people, the rest of them work, cooperate and perform as per certain agreed norms and standards. This leads to formation of groups. The construction of human groupings leads formation of a structure due to two reasons:

(a) Creation of division of labour i.e. placing individual at the appropriate place in order to utilise his specific skill or expertise, and

(b) hierarchy of operation i.e. to effect decision making at different levels depending upon its impact on achievement of goals. In addition, organisations have rules and procedures to handle specific situations.

Thus the organisational structure is an important factor which has a great bearing in the accomplishment of the organisational goals. The organisational structural design is not static; it has to undergo changes, may be minor or major, with changing environmental factors which affect the processes of fulfilment of its goals. The task of restructuring becomes more difficult and complicated as the size of the system grows over a period of time. Hence, after reaching every major milestone towards achievement of its goals the organisation should pause and review its structure. History is replete with very many instances where large organisations have gone 'down the drain' for not reorganising themselves to meet the changing environments.

B. Raghunathan is an ex-student of the M. Tech in "Management and Systems" at Centre for Management Studies, Indian Institute of Technology, New Delhi. He is a Colonel in Indian army.
The important steps involved in the re-structuring process include the identification of goals and breaking them down into sub-goals, grouping of logically connected activities and the determination of span of control of managers. The process is governed by a whole set of formal duties, tasks, relationships, policies, procedures, standards, rules, regulations and so on. The formal structure is presented in the form of charts, manuals, job descriptions, etc.

Till 1960s, the organisational analysis and understanding was dominated by Weber's idea of ideal bureaucracy [14]. Weber's discussion provided the framework for numerous studies, which provided evidence that, in practice, most large organisations did not resemble the ideal bureaucracy. Ideals from industrial psychology, social psychology, and sociology dealing with such issues as cohesion, leadership, job satisfaction and determinants of productivity raised further issues for organisational theory. In the 1960s the emphasis shifted from formulation of organisational theories to studies of organisational processes. As a result, studies dealt with smaller frameworks for studying the processes rather than comprehensive frameworks for studying the organisations as a whole. The emphasis also shifted towards obtaining practical advice for problem solving and decision making related to actual realities existed on ground. This led to the development of applied organisational science in the form of organisational design and development including studies on structure, technology and growth.

In mid 1970s the theory of group structures centred around study of micro processes of structural change in the small organisations. The pioneering work in this respect was carried out by Mackenzie [4,5] and was joined by Lippitt [3]. Mackenzie after an extensive study and research, developed a "Theory of Group Structures" [6,7]. Mackenzie [8] also applied the measure of degree of hierarchy to the problems of organisational design. The concept of power in organisational design has also been discussed and analysed by many authors. Mackenzie [9] identified a natural organisational phenomena called virtual positions to the enactment of power. A critical position is a composite position of a group of participating workers engaged as a recurring process, and it may be regulated virtual position. While analysing authority-task problems, Lippitt and Mackenzie [3] considered the problems of organisational analysis and design at two levels; a micro level dynamic problem solving organisation based on the task processes; and a macro level official organisation system which is comparatively static in nature. A review of literature on the organisational analysis and design is given by Sushil [12].

While carrying out organisational analysis for structural balance and stability many issues existing in the organisation need to be studied and analysed. They include, amongst other things, hierarchical relationships, chain of command, delegation of authority, authority-responsibility relationships, centralisation and so on. Amongst many concepts, the concept of authority-responsibility relationships plays an important role in the structuring of any organisation.

The current study is an attempt to design a technique for organisational structural analysis at micro level based on task processes with special reference to authority-responsibility relationships. In doing so, this technique uses the concepts and principles of Physical System Theory for analysing the authority-responsibility relationships.

1.2. Role of authority and responsibility in organisations

Managers at every level, in any organisation perform two important functions: planning and execution. The first step in the execution process is the establishment of organisational patterns which can contribute to the effective and efficient accomplishment of organisation's objectives. Intrinsic to this function are the concepts of ‘responsibility’ and ‘authority’. Authority and responsibility constitute the framework of organisational management – the basis on which any organisation is founded.

1.2.1. Authority

According to a dictionary definition, 'authority' is the legal or rightful power; a right to command or to act. Though the concept of authority can be viewed differently with different connotations, it can be broadly conceptualised and classified as the individual's right to pre-empt, direct, to act, decide and control. Authority is the sum of the powers and rights entrusted to make possible the performance of work delegated or
assigned. Authority includes such rights of power like spending specified amount of money, allocation of resources, hiring and firing of people. It may also include such powers as to render advice and provide service.

1.2.2. Responsibility

Responsibility, an inescapable corollary of authority, is the obligation one has to act in response to an order issued by higher authority. Responsibility indicates the individual's assumption of an obligation i.e. an agreement, promise, contract or recognition of duty. Responsibility also means what one is expected to do or not to do as a responsible person. Responsibility is also considered as the work assigned to a position or function. It encourages all mental and physical activities which must be performed to carry out a task or duty.

1.3. Authority and responsibility relationships

Responsibility, in the popular sense, is a containing obligation which arises from superior-subordinate relationship. This interpretation of responsibility to mean the obligation to do which is expected extends the concept beyond the superior-subordinate relationship to others in a group situation e.g. peers and associates.

Similarly, authority in organisations also revolves around its members. Authority is a form of power that does not imply force. Directives or orders are followed because it is believed that they ought to be followed. Compliance is voluntary, because all members of the organisation generally have the same value system.

As discussed earlier, based on the division of labour an hierarchical structure is formed in every organisation for accomplishment of its goals. All the components of the hierarchy have a specified task to perform. The members of the organisation are the agents through whom all the tasks get performed, the targets and goals get accomplished. Each manager in the hierarchy had to perform certain jobs assigned to him by the organisation. In an indirect sense these jobs can be termed as his responsibility, and to accomplish these tasks he is vested with certain resources and power to utilise them, which may be termed as his authority. For ensuring effectiveness in achievement of the goal, each manager fulfils the responsibilities rested on him with judicious use of the resources given to him in terms of authority.

It is a well known and accepted feature that for a manager to be effective he must be given adequate authority commensurate with his responsibilities. An imbalance in this equation will lead to, either emergence of an undesirable power centre or under utilisation of scare resources, and ultimately will lead to setting in of entropy in the organisation.

A delicate balance between authority and responsibility must be maintained in the entire hierarchy so that the organisation becomes effective. Though these two factors are widely discussed in literature, very few models are available which try to capture the reality existing in organisations. The quantitative analysis of these two highly abstract terms will lead to correct measurement of these factors leading to some prescriptive actions.

1.4. Role in organisational analysis and design

According to Pfeffer [11] organisational design is essentially a political process as well as a technical and theoretical problem. Kilmann [1] has defined the organisational design as “the arrangement and the process of arranging the organisation's structural characteristics to attain or improve the efficiency, effectiveness, and adaptability of the organisation". Organisational design has been considered as a maintenance process by Nyström and Starbuck [10] as the organisations are subjected to internal as well as external changes. The organisational maintenance cycle has been described by Mackenzie [8] in three phases: (i) Organisational Audit – to help in identifying organisational maladaptations; (ii) Organisational Analysis – to assess the probable impact of suggested changes; and (iii) Organisational Implementation – to install the planned changes.

The proposed model will have implications at all the three phases of organisation design cycle [12]. As the development of the model considers the details of activities being carried out at each managerial position it helps in identifying the inconsistencies and maladaptations during the Organisational Audit. The preparation of responsibility balance will indicate whether the man-
agers believe in delegation or there is growing unwillingness to accept responsibility. The values of authority and responsibility at each managerial position obtained from the model compared to the actual values will indicate whether there is parity between authority and responsibility. This will help in organisational design by balancing the authority-responsibility relationships at different levels of hierarchy. The sensitivity analysis of the model will help in categorizing the positions in the organisations into highly sensitive, moderately sensitive and less sensitive with respect to various coefficients. During organisational design the more sensitive positions should be assigned new responsibilities more carefully.

The maladaptation being identified during the Organisational Audit lead to the development of alternatives that are analysed in close interaction with the managers involved. During the Organisational Analysis various alternatives that can be attempted, to see the role of authority-responsibility relationships, are as follows:

(i) To analyse and observe that what happens if additional responsibilities are given at a managerial position, i.e. by what percentage the authority should be increased?

(ii) In order to meet the needs of some new activities or to reduce the imbalances in the organisational structure, or as a consequence of the design of information systems if there is a need to introduce new managerial position(s), or some positions are to be merged, what impact will it have on the authority-responsibility relationships? In what way the authority and responsibility should be redistributed?

(iii) To compare the consequences of centralisation and decentralisation decision on the authority-responsibility relationships. The responsibility coefficients in the proposed model can be appropriately changed and the values of authority and responsibility can be compared for different scenarios.

(iv) To analyse the interaction at different levels in terms of authority and responsibility leading to the determination of optimal delegation of authority.

The optimization can be attempted either by integrating the proposed system model with a mathematical programming (i.e. goal programming) model or by simulating the system model with different combinations of the authority responsibility relationships.

In view of the impact of various changes generated during the Organisational Analysis, final recommendations can be made and implemented regarding organisational restructuring during the Organisational implementation phase.

2. Quantification of authority and responsibility

In reality the concept of authority and responsibility are difficult to comprehend. However, for any meaningful analysis we need to devise a model to quantify these soft variables. The operational concept of these variables is utilised in their quantification, which could be carried out at micro and macro levels.

The micro level problem solving organisational structures are derived from the task processes using the theory of group structures developed by Mackenzie [4,5]. In the theory of group structures, structural changes are described as occurring by means of a voting process.

Lippitt and Mackenzie [3], after considerable research considered any organisation having three role systems, viz. task role system \( R_T \), authority role system \( R_A \) and official organisational chart \( R_C \).

The number of activities performed by a participant, indicated by '1' entries in the task role matrix is taken as a measure of responsibility of that participant. The authority has been considered as the legal right to preempt activities and is measured by the number of '1' entries for a participant in the authority role matrix. The unit

<table>
<thead>
<tr>
<th>Participant</th>
<th>Task activities</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a_1 )</td>
<td>( a_2 )</td>
</tr>
<tr>
<td>( X_1 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>( X_2 )</td>
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<tr>
<td>( X_3 )</td>
<td>1</td>
<td>0</td>
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<tr>
<td>( X_4 )</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>( X_5 )</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Performance of activity or responsibility for performance of an activity is denoted by an entry of '1'. Non-performance and non-responsibility is denoted by '0'.


authority i.e. authority per unit of responsibility is calculated by dividing the total authority of a participant by his/her total responsibility.

An example for a five person organisation, is shown in Table 1, 2 and 3 to illustrate the measures of responsibility and authority; only six activities are considered.

The measures of responsibility and unit authority, that can be utilised in the proposed model, for five participants are summarized in Table 4.

3. Authority responsibility function

An authority-responsibility function depicts the change in authority with respect to the increase in responsibility. An authority-responsibility function is represented either as a change of total authority with total responsibility; or as change of additional authority with total responsibility; or as change in unit authority (total or additional) with total responsibility. The additional authority at a position is the authority in addition to the authority of subordinates. The function $f(y)$ used in the model is representing the change of additional unit authority with total responsibility. The different kinds of authority-responsibility functions that can be used in the proposed model are described by Sushil [12].

4. Model

4.1. Physical System Theory – an overview

Physical System Theory (PST) is the result of pioneering work done by Koenig and his associates [2]. Its concept is based on the following:

The mathematical model of a component characterises the internal functional behaviour of that component, as measured at its interfaces irrespective of how the component is interconnected with other components to form a system.

In PST, based upon Linear Graph Theory, a two terminal component is represented by a linear oriented line segment, termed as an edge. Along each edge, two variables, “across” and “through” are measured with respect to two distinct terminals. “Across” variables exhibit different values at the terminals while the “through” variable remains the same at both the terminals.

The significant feature common to all types of systems, physical, socio-economic or otherwise, is that these are viewed as collections of discrete components joined at a finite number of points called the interfaces, through which they interact with each other. The components and their interconnections are represented by a system graph and the compatibility and continuity equations are defined for across and through variables which are considered as the generalisation of Kirchhoff’s voltage and current laws responsibility.
4.2. Modelling of organisational system using Physical System Theory

4.2.1. Components and interactions

Different managers at various levels are being considered as components of the organisational system. There can be \( L \) different hierarchical levels and \( n_l \) managers at each level. Then, the total number of components is \( \Sigma n_l \). Each component is interacting with some component at a higher level as well as a few components at a lower level. There can be uncle and cousin relationships as well.

The system model consists of individual component models, system graph and structural constraints [12].

4.2.2. Component model

The free body diagram of \( i \)th component (Manager), in case of pure hierarchical system is shown in Figure 1.

Let,

- \( X_i = \text{Unit authority (authority per unit responsibility) of } i \text{th manager} \)
- \( X_j = \text{Unit authority of } j \text{th manager (subordinate to } i \text{th manager) reported to } i \text{th manager} \)
- \( Y_i = \text{Responsibility of } i \text{th manager} \)
- \( Y_j = \text{Responsibility of } j \text{th manager (subordinate to } i \text{th manager) reported to } i \text{th manager} \)
- \( K_j = \text{Responsibility coefficient of } j \text{th subordinate} \)
- \( R_i = \text{Responsibility of } i \text{th manager under consideration} \)

\[ f_i = \text{Authority-responsibility coefficient of } i \text{th manager} \]
\[ = \text{Additional unit authority per unit of responsibility of the } i \text{th manager under consideration.} \]

Then, the authority equation is written as follows:

\[
- Y_i X_i = \sum_j Y_j X_j + f_i(Y_i) Y_i. \tag{1}
\]

Dividing both sides by \( Y_i \):

\[
- X_i = \sum_j K_j X_j + f_i(Y_i). \tag{2}
\]

The responsibility equations define the respective responsibility coefficients,

\[ Y_j = K_j Y_i \quad \forall j. \tag{3} \]

There will be, in all, \( \Sigma n_l \) component models.

4.2.3. System graph

The system graph is obtained by unifying the different component models in a one-to-one correspondence and by introducing dummy links connecting the lowest level and highest level nodes to a reference node. The reference node is introduced to close the system graph and acts as datum node with reference to which all the authorities are measured. The authority across dummy links, connecting first level nodes, may take any value zero, positive or negative. A zero value indicates that there is no lower level existing; a positive value indicates the existence of one or more lower levels, whereas a negative entry indicates a reporting from higher level to a lower level (which is, usually, not in practice). The dummy links also help in making the organisational system compatible, which may not be so in real life.

The system graph is to be divided into tree and cotree. The system graph with \( e \) edges and \( v \) vertices has \((v - 1)\) tree branches and \((e - v + 1)\) cotree chords.

4.2.4. Continuity constraints

This is the generalisation of the Kirchhoff's Current Law (GKCL), according to which the
sum of through variables for a cut-set of edges is equal to zero. In this case for a particular relationship:

Responsibility of any manager reported to immediate peer/superior

4.2.5. Compatibility constraints

This is the generalisation of Kirchhoff's Voltage Law (GKVL), according to which the sum of across variables for a circuit of edges is zero. In this case for a particular relationship:

Unit authority of any manager as reported to immediate peer/superior

Responsibility balance equations: In case of ideal or total delegation (where the role of superior is of a coordinator), the responsibility of the superior will be equal to the sum of responsibility of all the subordinates, i.e.,

\[ Y_i = \sum Y_j. \tag{4} \]

In this case the sum of responsibility at each level will be same. But in practice, this is not the case. The responsibility of \( i \)th superior, i.e. the equation (4) can be generalised as

\[ Y_i = \sum Y_j \pm R_i. \tag{5} \]

where \( R_i \) is the responsibility gap/surplus with \( i \)th level.

4.3. Implications of coefficients and constraints in the model

The proposed model is having two types of coefficients, viz. responsibility coefficient \((K)\), and authority-responsibility coefficient \((f)\). The responsibility coefficients define the structure of the organisational system in terms of the ratios of responsibilities of subordinates and the manager. This implicitly assumes that in an organisational system, responsibilities across two adjoining levels are maintained in a fixed ratio. If the overall responsibilities are increasing or decreasing, these are apportioned to various managers in the similar proportions without affecting their respective responsibility relationships.

The authority-responsibility coefficients \((f)\) in the model are able to take care of the pattern of change in authority at a particular level with the change of responsibility. Various authority-responsibility functions have been defined by Sushil [12].

The model incorporates two types of constraints, viz. continuity constraints and compatibility constraints, which define that the responsibility or authority of any manager is equal to the responsibility or authority reported to immediate superior. This implies that there are no perception gaps between two managers about their authority or responsibility. Such an assumption is true for a rational-legal type of organisation [14], which is taken as a basis for analysis. This may be a somewhat strong assumption in certain cases, and the methodology can be gradually modified to suit the organisations not following the mechanistic form.

4.4. Model validation

The model considers a rational-legal type of organisation as a basis which according to Weber [14], with its bureaucratic organisational form, is the final stage in depersonalisation, and considers organisations as sets of officials whose roles are circumscribed by written definitions of their authority. The apportioning of authority and/or assigning responsibility generated by the model using the parity of authority and responsibility respectively is to be compared with actual allocation of the authorities and/or responsibilities in the organisational system respectively. The difference, if any, between the model results and actual values of authority-responsibility for different managerial positions indicate the imbalances in the allocation of authority and/or responsibility to various positions. There may be various causes for such an imbalance. One important factor is the variation in the individual capability and experience of managers in position. Hence, if there is an imbalance between two managerial positions about the allocation of authority/responsibility, the individual capabilities and expertise of the managers in position should be compared. If there is no significant difference between the two managers then it can be concluded that the imbalance is there in the structure of the organisation.
In order to effectively consider these aspects in the model, the model can be expanded to take care of a third variable, i.e. managerial effectiveness. For this purpose the extended framework of physical system theory, as proposed by Sushil [13], can be used, in which the managerial effectiveness can be used as a quality variable.

5. Development of software

By developing a user friendly software, on PC, it is proposed to make this model more useful to the managers including those who do not possess working knowledge of computer. The proposed model is section 4 is operationalised by developing an interactive decision support system for organisational analysis named OASIS (Organisational Analysis with Interactive System).

5.1. Qualitative requirements of software

A requirement analysis was carried out to assess the required qualities of the software to be developed for organisational analysis. They are as follows:
(a) To be based on microprocessors: Considering the proliferation of microprocessors in the form of PCs (Personal Computers) the software should be developed based on the facilities available on microprocessors. This will enable even the medium size organisations to use PC and this software for analysis.
(b) Database manipulation facilities: The strength of the software to be developed is in its ability to create, view, modify, edit the database that is used for the analysis. This will facilitate the analyst in carrying out the cause-effect analysis of changes that he would like to incorporate. Popularly known as 'what-if' analysis, on-line, gives added advantage to the analyst, to quickly see the changes that take place with respect to changes in the input data. Such a facility is possible only in some special purpose packages like DBase III plus, Lotus and other electronic spread sheets, in the PC environment.
(c) Interactive facility: It has been appreciated that the organisation analyst may be from any discipline of science or engineering and hence, he should face no problem in using a software based and developed on Personal Computer. The programs should be user friendly and should proceed logically, taking inputs through interactive messages and computer prompting. In addition, some of the software packages available on PCs lend themselves to development of user-friendly and interactive programs. In short, the interactive facility offers the analyst a tool to carry out on-line analysis of databases.

5.2. Selection of suitable language

For Personal Computers (PCs) very many high level languages are available in the form of compilers such as COBOL, FORTRAN, Turbo C, Pascal and so on. An analysis of the facilities of the above languages indicate that they do not provide an easy approach to handle the databases. That is, the data base files can not be modified easily, to facilitate the analyst to edit or modify the data in the course of his simulation runs. However, a powerful package in the form of DBase III Plus is available for use in the PC environment. The package offers a powerful and flexible system for Data Base Management System for microcomputers. The package is very useful for creating, storing, sorting, organising, analysing and retrieving information on a micro computer. It is very user friendly and provides on-line menus for the user for interaction with this package.

Though this package offers facilities for manipulations of data bases, its efficiency in the applications of scientific nature is very limited. The package does not provide array handling facility, scientific calculations with experimental functions and trigonometric or statistical computations. The package’s efficiency in data base handling is considered supreme and because of this reason DBase III Plus has been chosen as the appropriate package for the development of the software.

5.3. Overview of logic

In any interactive software, the user must be taken through logical steps for his analysis of use of the software. The basic four steps that are involved in any analysis of database systems are:
(a) Creation of data bases
(b) Validation of data bases
(c) Edit/modification of data bases
(d) Generation of output/analysis

5.4. Menu assistance

To obtain a higher degree of user friendliness, the software package should take the analyst through logical steps, with each step offering all possible operations or processes. This is generally achieved through user friendly ‘MENU’. The ‘MENU’ is a dialogue between the software system and the system analyst. This arrangement is more effective under the circumstances where the analyst is not very conversant with the package or the software. Over a period of time, he may develop adequate expertise to handle the package. The ‘MENU’ assistance with OASIS is given in Appendix 1.

5.5. Creation of data bases

5.5.1. Task role matrix

The first data base to be created is the task role matrix. To create the task role matrix the following procedure is adopted:

(a) All the tasks are broken down to possible subtasks or sub-sub tasks and are numbered.
(b) With respect to each member, each sub-sub task is assessed for his responsibility (towards the sub-sub task). This is accomplished by a voting process, by taking the opinion of the member, his boss, and his subordinate (where applicable). This data is analysed based on a logic, that if all of them agree on the responsibility of a sub-sub task the member is assigned that responsibility.

The discrepancies are resolved, in case where the boss’s view differs from the member’s view. Thus an intermediate file called “Responsibility Determination File (Role-Det)” is created.

(c) From this Role-Det file, task role matrix is created giving the member-wise responsibility units.

5.5.2. Authority role matrix

The creation of the authority role matrix is similar to the task role matrix. The following steps are followed in creation of the data base:

(a) All the tasks that are broken down to sub-sub tasks are considered for preemptivity by each member.
(b) With respect to each sub unit of task, the opinion of the member, his boss and his subordinate is taken. Where all of them concur that the authority to preempt is that of the concerned member, he is assigned the authority. The task where discrepancies arise are resolved and appropriately the authorities are assigned to the member.

(c) Thus, an intermediate file giving the authority determination file (Auth-Det) is created.
(d) From this file an authority role matrix is created giving the details of participant/memberwise authority units.

5.5.3. Unit authority

After creating the data bases for responsibility (task role matrix) and authority (authority role matrix), a third data base is created called “unit authority matrix”. This data base file indicates the memberwise responsibility and authority and the unit authority of each member.

5.5.4. Organisation chart

The next important data base is the organisation chart which indicates the hierarchical levels existing in an organisation. The data can be captured for organisation chart and can be filled on-line by invoking the ‘CREATE Command’. The data base indicates, with respect to each member, the level, the members who report to him and the total number of such members. From this data base, the other processing for generation of equations start. The data base before its use for generation of equations correct its level and creates dummy levels at the top (where necessary) and at the bottom.

5.6. Validation of data bases

It is very essential that all the data bases created are validated before they are used for further processing. Validation programs have been written to validate all the data bases.

5.6.1. Task role matrix

The validation of the task role matrix involves the following checks on the data base:

(a) Maximum responsibility units will be given on the screen along with the member who has
the maximum responsibility and the responsibility units.
(b) Tasks which have not been assigned to any member.
(c) Tasks and the number of members who have been assigned this task.

5.6.2. Authority role matrix

The validation of the authority role matrix have the following checks:
(a) The maximum authority assigned to a member and the minimum authority assigned to a member.
(b) Activity which has not been assigned to any member.
(c) Activities which have more than one/two members who have authority to preempt.

5.6.3. Organisation chart

In case of organisation chart the validations built-in are as follows:
(a) No member can report to himself.
(b) No member can report to two persons.
(c) If top most level has more than one member, it will automatically generate a dummy member to whom others will report.

5.7. Generation of equations and solving of equations

There are two types of equations that are generated based on the information contained in the databases. These are unit authority equations and responsibility equations. The responsibility equations generate the responsibility quotient of each member, given the total responsibility. Similarly the unit authority equations generate the authority quotient of each member, given the individual’s inherent additional authority function \((F_O = C_O - M_O Y_O)\). The continuity and compatibility constraints are inbuilt in the generation of the responsibility and unit authority equations.

5.7.1. Responsibility equations

For generating the responsibility (flow) equations the programme ‘ORG FLOW’ uses data base of organisation chart and the responsibility chart. The following logical steps are followed to generate flow equations:

(a) Organisation chart data base is invoked.
(b) Member record is read. (Say Member 1)
(c) Each member’s record is scanned to see who are the members who report to this member, i.e., members who report to Member 1.
(d) With respect to each member who reports to the member (i.e., Member 1) a flow equation is generated. e.g. If Member 2, and Member 3 report to Member 1 then two equations will be generated. Each equation will be stored as a record. In this example the following equations will be generated:
\[
Y_2 = K_2Y_1, \\
Y_3 = K_3Y_1.
\]
(e) Thus an intermediate file will be created, having a record for each of the equations. The fields of the intermediate files are Left side \(Y\) (LY), Right side \(Y\), KVALUE (KVAL) and YVALUE (YVAL).
(f) This file once created, will be used to compute the K Value.
(g) The programme prompts (asks) for the initial value of \(Y\) i.e., total responsibility value. In this example, the initial value of \(Y\) will be given.
(h) Subsequently, the programme takes each equation and solves them progressively. The left side \(Y\) value is obtained from responsibility data base of the corresponding member. The right side \(Y\) value is either given on line or has been computed based on the already supplied value. Based on YVALUE of left and right side the KVALUE is computed.
(j) The programme lists the equations and gives the \(Y\) value of each member.

5.7.2. Unit authority equations

The unit authority equations are generated by the programme ‘ORGCOST1’. It makes use of the data base created for organisation chart and the \(K\) values computed by the flow equations. In addition, the programme also makes use of the data base which gives individual members authority quotient. The following logical steps are followed in the generation of unit authority equation (\(X\) equation):

(a) The organisation chart data base is invoked.
(b) Each member’s record is scanned (say Member 1 record is under scan).
(c) All the members who report to the current record are identified, e.g., Member 2 and Member 3 report to Member 1.

(d) With respect to current member the equation generated is
\[ X_1 = K_2 X_2 + K_3 X_3 + F_1. \]

(e) The parameters of this equation are captured in intermediate data base file.

(f) Once all the equations are generated and stored, the intermediate file is opened and scanned from bottom.

(g) The initial values of authority of dummy members will be equal to \( F \) values which is automatically obtained from the data base file \( FVALUE \).

(h) The \( K \) values are obtained from flow equation data base.

(i) The right side \( X \) value are obtained by scanning the current data base file and the left side \( X \) value is computed.

(k) The equations are printed.

(l) The \( X \) values are computed and printed.

The software has been based on the facilities available on the package DBASE III Plus. The present limitations of array handling can be overcome in the new version of DBASE IV Plus which is likely to become popular shortly. The authors have already started updating the software with some additional features in DBASE IV.

6. Illustrative example

An organisational system is represented by hierarchy of managers placed at different levels, having varying degree of authority and responsibility. Every manager in the organisation has been conceptualised as a multi-terminal component interacting with some component at the higher, as well as lower levels of hierarchy. Each interaction has been considered as a two terminal component. The unit authority across two levels is different and hence taken as an across variable 'X'; the responsibility which flows through the organisation is considered as a through variable 'Y'. This modeling technique can be applied at any level in the organisation.

The proposed model is illustrated by applying it to a hypothetical organisational system with twelve managerial positions at three hierarchical levels, as shown in Figure 2, and thirteen activities. The input data and results for this example are shown in Appendix 2. The system model for the example given by Sushil [12] is used for validation of the software developed.

If measure of actual authority are known the calculated values can be compared with them to assess the variation in practice from the parity of authority and responsibility. If it is a new organisation to be designed the values of authority derived from the model will act as a guideline to distribute the rights among various managerial positions.

7. Applicability of software

In a study of this nature where one tries to fathom the unexplored avenues and techniques, it is possible to come across such findings which may be really baffling or quite intriguing. During this project, the conversion of a popular technique, Physical System Theory (PST) for adoption under the PC environment threw light on many issues.

Firstly, the versatility of an analytic tool like PST, which otherwise was thought to be an engineering (electrical) technique of analysis was revealed. The concepts of PST can be effectively used for analysis of authority-responsibility relationships. The analysis and measurement of re-
responsibility alone will suffice to generate the authority, so that the disparities can be identified.

Secondly, the software package DBase III Plus has been proved to be a very useful package for organisational analysis. The package, though not designed for scientific applications, can be used for limited scientific applications through innovative techniques. The array handling algorithm is one such example, where the existing facilities can be modified for limited scientific applications.

Thirdly, this software package which is user friendly and interactive can be used for 'what-if' analysis; to see the changes of responsibilities at any managerial position and the quantum of authority required to balance the structure.

Fourthly, this interactive package will also analyse the implications of introduction of new activities or new managerial positions to meet changing environmental conditions, especially in places where organisations are being revamped or reorganised.

Fifthly, the model can be effectively used for analysing the cause effect relationships of centralisation versus decentralisation. The responsibility coefficient can be changed and the values of authority and responsibility can be compared for different scenarios.

Lastly, the software package has opened new avenues for organisational analysis. The programmes, the data base structures and the menus can be easily amended to add or modify the existing logic of processing.

8. Concluding remarks

Based on the experience gained in preparing this package, certain useful and meaningful points have emerged which would make this technique more realistic and useful for analysts. However, we may have included and integrated certain other factors such as managerial effectiveness, delegation of authority, power in organisations, virtual position; line-staff relationships and so on. These factors can be taken one by one, and integrated into this model to make it more versatile.

Future analysts, must also enhance the user friendliness of the software by incorporating graphic design for drawing up organisation chart and developing an ideal organisation based on the need and norms.

In addition, the concepts of Physical System Theory (PST) used to enrich the organisational analysis may be further strengthened with other qualitative techniques for data capture and data base creation. For example use of 'Fuzzy-Sets' for analysis will facilitate the capture of data regarding authority and responsibility.

This technique can further be explored for adoption in the analysis of Project Management environment for review and allocation of managerial resources based on intensiveness of activities.

In this study, the concepts of PST have been used for the first time in developing a model that will facilitate organisational analysis. Again for the first time, an attempt has been made to develop an Interactive Decision Support System for Organisational Analysis (OASIS).

It is sincerely hoped, the humble beginning which has been made, if properly explored may open-up new frontiers for the quantitative analysis and design of organisational systems.

The future of this technique, of course, will depend largely on the interactions and suggestions it will receive from practising managers.

References


Appendix I

MENU ASSISTANCE WITH OASIS

MAIN MENU
1. CREATE DATABASES
2. VALIDATE DATABASES
3. EDIT DATABASES
4. GENERATE EQUATIONS
5. SOLVE EQUATIONS
6. EXIT FROM OASIS

ENTER YOUR CHOICE:

CREATE MAIN DATABASE FILES
1. CREATE AUTHORITY DATABASE
2. CREATE RESPONSIBILITY DATABASE
3. CREATE ORGANISATIONAL CHART
4. CREATE FUNCTION FILES

ENTER YOUR CHOICE:

(Press any key to get previous menu)

DATABASE VALIDATION
1. VALIDATE AUTHORITY DATABASE
2. VALIDATE RESPONSIBILITY DATABASE
3. VALIDATE ORGANISATIONAL CHART

ENTER YOUR CHOICE;

(Press any key to get previous menu)

EDITING DATABASES
1. EDIT AUTHORITY DATABASE
2. EDIT RESPONSIBILITY DATABASE
3. EDIT ORGANISATIONAL DATABASE

ENTER YOUR CHOICE:

(Press any key to get previous menu)

GENERATING EQUATIONS
1. GENERATION OF RESPONSIBILITY EQUATIONS
2. GENERATION OF UNIT-AUTHORITY EQUATIONS

ENTER YOUR CHOICE:

(Press any key to get previous menu)

GENERATION OF EQUATIONS & SOLUTIONS
1. SOLUTION OF RESPONSIBILITY EQUATIONS
2. SOLUTION OF UNIT-AUTHORITY EQUATIONS

ENTER YOUR CHOICE:

(Press any key to get previous menu)
## Appendix 2. Parameters and results of illustrative example

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(e) Values of authority-responsibility functions

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(h) Comparison table

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AUTH = AUTHORITY
RES = RESPONSIBILITY