

Visual Thinking in Organizational Analysis

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ABSTRACT

The ability to visualize the relationships among elements of large complex databases is a trend which is yielding new insights into several fields. I will demonstrate the use of 'visual thinking' as an analytical tool to the analysis of formal, complex organizations. Recent developments in organizational design and office automation are making the visual analysis of workflows possible. An analytical mental model of organizational functioning can be built upon a depiction of information flows among work group members.

The dynamics of organizational functioning can be described in terms of six essential processes. Furthermore, each of these sub-systems develop within a staged cycle referred to as an enneagram model. Together these mental models present a visual metaphor of healthy function in large formal organizations; both in static and dynamic terms. These models can be used to depict the 'state' of an organization at points in time by linking each process to quantitative data taken from the monitoring the flow of information in computer networks.

1. INTRODUCTION

The ability to visualize the relationships among elements of large complex databases is a trend which is yielding new insights into several fields¹. Most applications of visual thinking have been in scientific and technical fields where visual metaphors of underlying processes exist (i.e., molecular chemistry, astronomy). This paper proposes to extend the use of 'visual thinking' as an analytical tool to the analysis of formal, complex organizations. The analysis of large, complex organizations is becoming a critical function for executives in environments of increased competition. Historically this analysis has taken the form of numeric, quantitative reasoning. These methods appear to be inadequate to offer explanatory power in emerging forms of organizations. A new metaphor is required.

Recent developments in organizational design and office automation are making the visual analysis of workflows possible². Workflow software designed to enhance work group effectiveness is entering large corporations and beginning to spread to smaller units with the advent of local area networks, ISDN and more powerful computer platforms. These products are build around graphical user interfaces and visual programming languages. Users are constructing visual models of their work patterns. A representation of organizational functioning can be built upon a model of information flows among work group members.

This paper is composed of three sections. The first examines the traditional view of organizational functioning as a basis for extending a structural metaphor into a more dynamic form. This new paradigm for organizational analysis is explained in terms of its major components of organizational functioning. The second section of the paper describes the current information theory view of an organization--as systems of information flows. The linkage between organizational process and information system structure is then proposed as a basis for organizational analysis. The last section of the paper proposes that this new model presents an opportunity for scientists, researchers and managers alike to utilize advanced visualization techniques as a methodology of analysis. In conclusion, the paper offers a path forward for researchers.

2. ORGANIZATIONAL PROCESS

2.1 Elements of Organizational analysis

Sociological explanations and descriptions of organizations are concerned with two important properties of organizing behavior: structure and function. Structure refers to measurable, observable patterns of communication that persist over time³. Computers not only affect organizations, but in some ways are organizations. This is especially true in large, complex, formal organizations where computers are applied in everything from the electronic exchange of memos to the control of heat and lights in the building.

Organizational theories usually explain the structure and function of corporations in terms of authority and power, size and complexity, efficiency and effectiveness, information, technology, and environmental influences. While different theories emphasize different variables at different times, all theories implicitly or explicitly describe organizations with these constructs. Sociological theories of organizations differ from cognitive and social psychological theories, in that they concentrate more on general observable trends than on the magnitude of variable relationships, a situation dictated partially by the difficulty in obtaining quantitative data. Organizational theories are concerned with identifying consistent patterns of communication between individuals (i.e., structure). The purpose of these theoretical formulations is to provide a framework for comparative analysis of organizations. These traditional theories have been found wanting in terms of this explanatory power as technology has begun to fundamentally alter the time and space relationships of work activity.

The structural nature of the workplace is changing. The established industrial order is giving way to more streamlined ways of work. Flatter organizations, insistence on quality and self-managing groups are demand forces requiring a new generation of software that augments these new organizational styles. The use of electronic forms of symbolic communication is increasing the bandwidth of human-computer interaction. Images, graphs, charts and iconic symbols are routinely used to facilitate communication. Computing power is moving toward provision of enormous graphical power for the end user. One of the most current developments is the use of computers combined with telecommunications networks to extend the workplace in time and space. The most important change we will see in work computing technology will be an ability to separate coordinated work processes in time, space and make this VISIBLE to everyone using the system. Organizational structures are being modified along lines distinct from the typical methodologies referred to above. The salient points of these changes are:

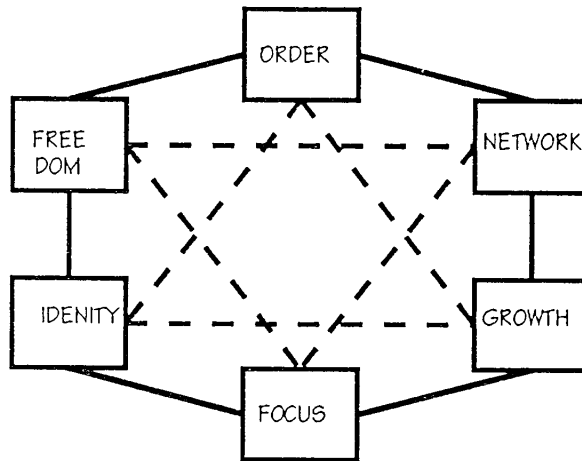
- **Time Shift.** A move from asynchronous, serial processing to parallel work processes.
- **Space separation.** De-centralization of white collar work force. Reduction in use of office space by 30% by 1995. Reversal of trend to separate home and office location. Tele-work centers in ex-urban areas.
- **Visibility.** Graphical representation of work process in real time. The 'virtual workplace' becomes a reality. Visibility of process allows increased use of simulation of commerce to test impacts of alternative action.

2.2 Bennett's Hexad Structure

John Bennett sought to explain systematic functioning of complex organisms by way of developing multi-termed visual models⁴. The model that Bennett developed which closely

resembles a modern complex social organization is called a 'hexad' because it contains 'six terms' or elements. The hexad represents a coalescence of time and space dimensions of different processes which occur when an organism is becoming, or more to our point, evolving. According to Bennett, this structural model formed the essential basis for the dynamic nature of organisms. I have adapted this model in my work with organizational change efforts as a metaphor of organizational robustness. The model has proven to be an excellent diagnostic tool which parallels work done by socio-technical systems practitioners. Figure 1 is a diagram of the six terms and their relationship in triads, and as a whole system. I hypothesize that these elements can be defined in a way which allows them to be linked to the flow of information within the organization.

Figure 1



2.2.1 Definition of Terms

Growth-- Realization of greater range in terms of absolute size or market penetration; a measure of scale. Growth can also be realized as combination with other entities in symbiotic form.

Focus--Development of efficiency in operation; a measure of variance reduction in output. Concentration of effort to eliminate waste is process.

Freedom--Rate of innovation; a measure of creation. An opening to possibilities to develop ideas, products or processes which currently do not exist in the organization.

Order--Relationship of steps within a productive process; a measure of sequencing. A measure of internal efficiency.

Identity--Definition of uniqueness; a measure of salience to environment. Also related to definition of boundaries of the organization.

Networks-- Interaction pattern, both internal and external; a measure of pace and density, connectedness and reciprocity.

For Bennett, each of these terms held special significance because they were founded upon more elemental 'laws of interaction'. Although these laws can be used as a basis for intervention in organizational processes; the point here is to identify operational definitions of organizational

functions which can be tested for validity and reliability with data which describes information flows.

3. INFORMATION FLOW ANALYSIS

3.1 Structural Change

The form and function of large, complex industrial organizations are changing as a artifact of increased use of advanced communication technologies. A quote from a recent analysis of the topic illustrates this point:

"Advancements in management information technologies in the past half decade are bringing to organizations forms and functions unanticipated even a few years ago. The revolution in personal communication and computation power is changing organizational roles and tasks and is offering increased effectiveness and productivity to organizational designers who choose to take advantage of technological innovations." ⁵.

When these changes take place, the empirical question becomes " what are the patterns to these changes in organizational form and function?" My hypothesis is that these structural forms can be understood as changes in information flow patterns and are comprehended best as visualizations of these patterns.

3.2 Network Analysis

Network analysis has been employed in several social science disciplines to provide graphical representation of complex communication structures⁶. Looking at information networks as a metaphor for organizations is becoming more relevant with development of increasingly dense communication structures⁷. Indeed, the cybernetic model of organizations is quickly becoming a dominant metaphor of analysis ⁸.

A network picture of an organization includes nodes, pathways, transformational rules and form and content. what moves, or flows, through these networks is information in its raw form. Moreover, we may say that it is data that flows; and only becomes information when viewed IN CONTEXT of the organizational structure. Data is information in the context of the MODEL of the organization. Above, I have proposed one model of the organization. I suggest at this point of theory development that reliability of the model is more important than validity--which will be determined after empirical testing.

3.3 Contrasting Views of Information

In order to translate our function model of an organization (Figure 1) and our process model (Figure 2) into operational definitions of variables we must first carefully define information flows. Communication theorists have traditionally looked upon information as an entity; a particle⁹. This view has fit well with database models (i.e., entity-relationship models) and also with the management science perspective of variance theory ⁷. In some ways this approach is analogous to physics view of energy as 'particles.'

The developing view of information is much more process oriented^{7,10}. In process theories, "....outcomes are not conceived as variables that can take on a range of values, but rather as discrete or discontinuous phenomena that might be called 'changes of state'.⁷". This distinction is important to developing a visual model of the organization. Bennett's hexad model is comprised of different 'levels of energy', or discrete states, within each functional element (i.e., growth,

focus, etc.). An organization moves from one level to the next as it completes the transit of process described in the enneagram. Therefore, a process model of organizational information flows fits conceptually with Bennett's visual images of organic process and structure. The view of information, then, becomes more like a 'wave' theory of energy with differing 'levels of energy'.

3.4 Relationship of Process and Structure

Bennett's models can be used to depict the 'state' of an organization at points in time by linking each functional process to quantitative data taken from the monitoring the flow of information in the organization's computer network. Each of these information flow analogs can be construed as a variable describing a social communication network ¹¹.

Communication networks have many characteristics which can be related to their function and effect upon members of the network: size, connectedness, density, content of communication, form and reciprocity. If we examine the network literature, in the context of operationalizing the hexad model of Bennett we find the following information flow analogs:

Table 1

Organizational Process	Information Flow Analog
Growth	Normalized volume
Focus	Variation in output (products or service type)
Freedom	Creation rate of information 'objects'
Order	Degree of indexing of information
Identity	Amount of reference to business entity (internal and external)
Networks	Density of communication

The need for brevity in this paper prevents an extended discussion of development of these analogs. However, in general, Growth is seen as an indicator of scale of communication and number of nodes in the network; normalized to control for non-reciprocal communication. Focus, in turn, can be viewed as a measure of non-variation in categories of communication; one topic of conversation is more focused than five topics. Freedom can be taken as amount of creation taking place; the development of new topics of conversation expressed as 'objects, folders, files, etc.). Order has to do with specification and definition of sequence, or scheduling. Identity is a self-referential function; a measure of distinctiveness and recognition of boundary. Networks is a measure of communication interaction, or density.

4. VISUAL THINKING

4.1 Development of Data Models

Visualization of organizational data has a rich history¹². The ubiquitous organizational chart is a prime example. While these methods of displaying hierarchical authority structures are adequate for relatively stable, formal organizations; their use is marginal with the development of more fluid, information based organizational structures. Organizational re-design techniques ¹³ employ a variety of graphical techniques for creating visual representation of work flow, authority structures and boundary conditions for large, complex organizations.

The use of visual models to depict data flow is a technique commonly used in computer programming. Flow charting techniques have been employed to clarify the pattern of data flow and control structures for decades. It is commonly understood, that visualizing complex information structures helps clarify the processes which are being automated. The advent of object-oriented programming (OOP) has made this visualization process even more central to the design of computer programs.

These methodologies of using visualization techniques to display complex data have been explicated quite well by demographers^{1,12}. Cognitive psychology has understood for quite some time that the human brain has an innate capacity to recognize complex patterns and structures when they are displayed in visual fashion. The recent advances in computer technology are now allowing us to expand our visualization ability and apply enormous compute power in new areas. The areas which show most promise are those where complex patterns develop over relatively longer periods of time, (e.g., weather forecasting and demographics) or relatively short time spans such as chemical reactions, and thermodynamics.

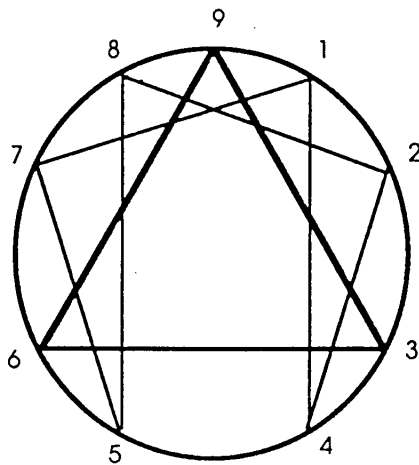
4.2 Virtual Reality as an Analytic Technique

Computer technology is now about to give us a new method of displaying complex data in a visual modality. Currently termed Virtual Reality (VR), we are beginning to link people directly to computer so that they (humans) can use kinesthetic and visual modes to control computer operations¹⁴. It is now possible to navigate through a visual data base by controlling movement from data point to data point by pointing with your hand, moving your head or even more complex body movements. A single data point can be expanded (that is linked) to another data point with a snap of a finger or blink of an eye. The initial applications have been in architecture and molecular modelling.

I believe that one possible application of these VR technologies is in the field of organizational modelling and design. Until we have lacked a theoretical foundation to support data abstraction for VR techniques. I propose that the information flow model presented here is one avenue to be explored in this context. Visualizing three-dimensional (3D) data spaces is made easier with computer animation techniques. Cartesian coordinate systems can be manipulated to show different perspective and new insights emerge from visual interpretation of data relationships. However, this still is limited to a static display of data. Variables which are continuous in nature and dynamic are difficult to understand. I believe this difficulty is rooted in lack of a cognitive model of the dynamic change process.

I propose that a systematic model of ordered process could inform this interpretation process. Bennett's metaphysical systems contains such a model¹⁵. It is called an enneagram and is displayed here as Figure 2. The enneagram depicts the flow of ACTIVITY in any complete process. During the performance of a task activity moves around the outside circle in linear order from point to point. However, the cognitive process of planning (or mental anticipation) is best described by movement within the diagram moving along the path (1,4,2,8,5,7). Thus the distinction of difference between patterns for activity and planning for the activity. The correlation, so well displayed in the enneagram, between these differences is often confusing. I suggest then that this visual icon of the doing and thinking process for any work task can be used to visually depict where a process is located in the temporal dimension--a visualization of time sensitive work process.

Figure 2



4.3 Simulation Models

When these two cognitive models (Figures 1 and 2) are combined they produce a basis for simulating, in a visual fashion, the functioning of a complex organization based upon characteristics of information flow. The relatively static structures of communications patterns (form) are combined with a representation of flow dynamics (process). Use of historical data of information flows can then be used to test and correct the model. Algorithms of variable relationships can be created from this data. Algorithms can then be used with simulated data to test hypotheses of organizational functioning and 'what-if' scenarios can be constructed to test the impacts of various organizational design decisions.

5. CONCLUSIONS

5.1 Tools for Management Analysis

This brief outline presents a visual model of organizational functioning. The model can be used for diagnostic, analytical and simulation purposes to aid managers and executives in making practical business decisions. The model is an example of visual thinking applied to a new area of science and technology--organizational analysis. In the future as larger and more interconnected databases are constructed within organizations; visual metaphors will become a standard way of viewing the enterprise--the virtual reality of business.

As organizations expand over greater time and space regions models such as this will become a standard way of analyzing functioning and determination of relative success of alternative network forms. Information is rapidly becoming the commodity of service industries. Old models build upon a manufacturing of goods paradigm are no longer adequate to anticipate impacts of environmental or market changes¹⁶. Distributed data bases, wide-area-networks and increased graphical modelling power are all converging to provide powerful analytic tools. However, these tools are of little use without clearly articulated cognitive models of organizations. What has been proposed here is one possible model of complex organizations of the future.

I began this exposition by referring to the shift in time and space dimensions of organizational activity brought about by use of advanced communication technologies. It is my hypothesis that the understanding of **time** and **space** alterations can be more readily comprehended through techniques of visualization, than more traditional financial models. The cognitive maps (Figures 1 and 2) presented here provide an empirical model to map information flows in this context.

5.2 Next Steps

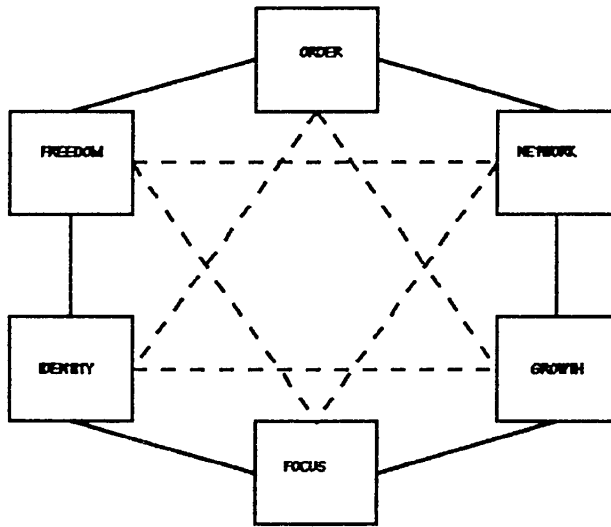
There are two significant next steps which must be undertaken to move theories of visualizing organizational functioning from theoretical statements, such as this paper, to useful management tools:

(1) **Further development of the models and approaches suggested here by empirical testing with existing data from corporate databases.** The technology of VR promises to provide a test bed for the future. Work is currently underway in several locations throughout the Us and Europe where these hypotheses could be tested. A union between organizational design theories, VR technology and management science is required.

(2) **Correlation of these visual models of information flows with existing financial models of the firm.** This work would bring together our knowledge of information flow within organizations with traditional business analysis, based upon financial figures. The integration of financial information with organizational functioning based on information flow could provide an empirical basis for development of a econometric exchange theory of information value.

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Dimensions of Organizations and Information Flow Analogs

Organizational Dimension	Operational Definition	Information Flow Analog
Growth	Measure of Organizational Scale coupled with Rate of Change	Normalized Volume 1st Order Derivative
Focus	Efficiency of Operation Output Variance Reduction	Variation in Output Types Standard Deviation
Autonomy	Rate of Innovation Measure of Creative Ability	Creation Rate of "Objects" 2nd Order Differential
Order	Measure of Sequencing of Operational Steps	Degree of Indexing of Objects Log-Linearity, Entropy
Identity	Measure of Uniqueness Boundary Permeability	Self References Degree of Translation
Network	Measure of Interaction Pattern Density and Reciprocity	Density of Communication Ratios of Frequency and Direction