1976

# THE NETWORK ALTERNATIVE:

## AN EXPLORATORY MEETING OF PRACTITIONERS, SOCIAL SCIENTISTS AND SPECIALISTS *

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## INTRODUCTION

The term "network" is encountered more and more frequently in the social sciences, in administrative documents and in public debate as reflected in the news media. In each case use of the term seems to be associated with new perceptions of the complex and subtle patterns of relationships between social structures characteristic of society today.

It becomes increasingly clear that social scientists and practitioners are seeking a new vocabulary, one that would provide a means for objectifying and de-mystifying the complexity of the organizational, problem, and other networks by which we are surrounded and within which our activity is embedded. At present, because clear and unambiguous concepts for discussion of social complexity are lacking or have very limited currency, communication can only be achieved with the aid of extremely cumbersome and lengthy phrases which tend to create more confusion than they eliminate. In the absence of adequate terms to handle urgent but complex realities, debate tends to concentrate on issues which can be adequately expressed via the traditional vocabularies. The same issues recur, maintaining a high level of visibility and an assumed legitimacy due to the relative ease with which they can be stated, rather than to their importance.

While the term "network" may be currently doing some service to contain the complexity with which social scientists and practitioners are confronted, there is a strong possibility that both groups could benefit from each others insights and from exposure to the more sophisticated forms of representation already developed by the small group of mathematicians concerned with networks (e.g. in the case of topology, graph theory and related disciplines).

The special advantage of using the term "network" as the point of departure is that it is capable of encompassing and inter-relating a great variety of social entities and links. This is in contrast to exclusive focus on partial

* Note: This proposal was substantially developed by Anthony J.N. Judge of the Union of International Associations, Brussels.

or fragmentary features of the social fabric, an approach which has been the cause of much difficulty in communication about social structures and processes.

## PROPOSAL

It is proposed that a small symposium be organized to allow the following groups to confront each other:

- mathematicians concerned with topology and graph theory but who are interested in the perceptions and needs of social scientists at this time;
- social scientists sensitive to the possibility that a more extensive use of topology/graph theory concepts could be used to clarify current thinking about inter-organizational structures and their relationship to problem complexes;
- other specialists involved in some way with conceptual handling of networks;
- practitioners using the concept of "network" and "networking" as a means of ordering their perception of the relationships between the organizations with and through which they work -- and who may be able to draw the attention of the other groups to types of complexity which they have difficulty in describing or anlayzing.

## OBJECTIVES

The purpose of the meeting would be to:

1. clarify how people work with, or through networks, how they perceive them and their characteristics, how they respond to them;
2. explore similarities and differences in order to define the interface between technical uses of the network concept and the use of the term by people obliged to respond consciously to networks encountered in their working life;
3. determine through interaction with people working with or through networks whether they may gain insight from those conceptualizing about networks in other

ways, so as to obtain a working structure within which to incorporate their intuitions; and to enhance their ability to think about, discuss and more efficiently work with networks;

4. identify those features or characteristics of networks which could usefully be more clearly described or labelled to facilitate the activities of practitioners and increase the precision of their discussion about those networks with which they deal;

5. provide an occasion for those conceptualizing about networks to obtain feedback on the relevance of some applications of the concepts they are developing and draw their attention to features of networks encountered in practice, on which inadequate conceptual work has been done, if such is the case;

6. explore the significance, if any, of preference for 'network' in place of 'system', and clarify the distinction, if any, indicated by this preference;

7. explore, if relevant, the modes of transition between systems and networks, whether in concept, in organization or in practice, in order to clarify what may be considered socially desirable or undesirable features of each.

8. determine the variety of social, economic, political, administrative and related domains in which the network concept is used as a means of ordering experiences and responses;

9. clarify the question of whether society may not be faced with a hidden problem, complementary to illiteracy and innumeracy, namely an inability amongst a significant proportion of the decision-making population to be able to handle structures and networks with the facility demanded by the degree of reticulation of society;

10. identify ways of improving the general ability of policy-makers, administrators, concerned citizens, researchers, etc. to engage in fruitful discussion about existing networks in society and the possible forms of alternative networks in a network-oriented society;

11. determine whether programmes could usefully be initiated, in support of the above, in such areas as:

    - education about networks, how to think about them, and how to work with them;
    - audio-visual portrayal of existing (or proposed alternative) networks, and the problems of designing and operating displays sufficiently powerful and detailed to be useful in practice (rather than simply for illustrative purposes);
    - surveys of networks and the degree of reticulation of societies and the relation to the debate on social indicators;
    - research required on networks.

PRACTICAL SIGNIFICANCE

Insights could usefully emerge which would be valuable to the following sectors, for example:

- international relations: description and analysis of inter-/intra-organizational relations, particularly where the interactions between distinct hierarchies become multiple and complex.
- sociology: as above but at the national and community level.
- community development: as above but possibly with an emphasis on alternative structural possibilities and increase in adaptability.
- urban development: as above.
- policy sciences: description and analysis of relations between clusters of identified problems, the actors concerned with them, and the resource flows applied to them.

An existing set of concepts relevant to the current condition would therefore acquire wider currency. By entering to a greater degree into the language used to describe the social complex, their relative sophistication will improve the response to complex situations, if only in terms of an increased ability to distinguish between types of complexity and to communicate unambiguously about them.

## TRANSNATIONAL CONTEXT

The proposal is a feature of the programme of the following transnational bodies which either have operational links or common memberships:

- Union of International Associations (Brussels)
- Mankind 2000 (Brussels)
- International Foundation for Social Innovation
- International Bureau For Professional Development

Several other bodies might wish to be associated with further work in this area. They include: World Future Studies Federation, Inter-University Center for Postgraduate Studies, United Nations University.

## PRODUCT OF THE MEETING

The main purpose of the meeting is to explore the possibility of obtaining useful products from further work in this area as outlined above.

This meeting could however give rise to the following products to serve as a benchmark for any further explorations (whether on the part of the amateur conceptualizer or the hardcase practitioner):

1. Select bibliography of papers and sources;
2. Roster of people or bodies relevant to exploration of particular aspects of the subject area;
3. List of topics for meaningful theses;
4. Draft of a structured glossary of network terms with indication of characteristics for which unambiguous terms are lacking;
5. Annotated list of human activities in which the network concept is of potential or actual use, possibly ranked in order of susceptibility to such use (possibly with selected quotes from texts in each area, illustrating any such use). Such information could also be ordered to clarify the time when such a perspective becomes appropriate in the evaluation of a particular domain;
6. A collection of audio-visual materials providing visual support for any network perspective.
7. The basis for a collection of papers which could be used to develop a reader for this area.

PROGRAMME OUTLINE

A - Structural features of networks: key concepts

- Processes within networks: key concepts
- Growth of networks (development of existing structures): key concepts
- Evolution of networks (emergence of new structures): key concepts

B - Movement of individuals within networks, and their understanding of them

- Working with networks
- Education about networks

C - Strong and weakpoints of networks and their detection

- Controlled (centralized) versus relatively uncontrolled (decentralized) networks
- Network auto-coordination and network strategy

D - Visual representation of changing complex networks

- Computer software for network analysis
- Computer software for network map generation on CRTs and graph plotters

E - Alternative kinds of networks; networks in the future

- Networks versus systems and hierarchies.

CURRENT EXAMPLES OF THE USE OF "NETWORK"

A. United Nations

United Nations University "The major work of the United Nations University will be conducted through "networks". Thus, very careful consideration must be given to the organizational implications of conceiving, creating, managing, monitoring, and utilising networks. Unfortunately, this is an exceedingly difficult area to conceptualize in the abstract, outside the context of specific programme objectives. It is even more difficult to imagine what may be required in terms of central management functions until there is some actual experience to draw upon." (UNU/C/Session 7/L.5, Annex IV, page 11).

United Nations International System for Information on Science and Technology "UNISIST is a continuing, flexible programme based on a joint Unesco-ICSU Study whose aims are to coordinate existing trends towards cooperation and to act as a catalyst for the necessary developments in scientific and technical information. The ultimate goal is the establishment of a flexible and loosely connected network of information services based on voluntary cooperation." (UNISIST Newsletter, 1, Jan 1973, page 2).

Multinational Corporations in World Development "While the terms"corporation", "firm" and "company" are generally used interchangeably, the term "enterprise" is sometimes preferred as clearly including a network of corporate and non-corporate entities in different countries joined together by ties of ownership." "By contrast, most developed host countries belong to a network of advanced economic, and even political, relationships which allow for more successful economic and political bargaining." (ECOSOC report on Multinational Corporations in World Development, pages 4 and 45).

Agricultural Policies "The existence of an extended network of domestic agricultural policies in the developed countries has important consequences. It must be recognized that a network of such measures provides an effective barrier against any sudden large-scale contraction of agricultural incomes such as occurred in the great depression of the early 1930s" (FAO. Commodity Surplus, 1 1964, page 14).

B. Social Networks

"Society is not a crowd or cluster or clump of human beings; it is a set of networks of relations among human beings.

Every human being is linked with others in a number of networks which are not mutually exclusive and are also not coextensive with each other." (Arnold Toynbee. Aspects of Psycho-history. Main Currents in Modern Thought, 1972).

"When Radcliffe-Brown. . . defined social structure as 'a network of actually existing social relationships'. . . he was using 'network' in a metaphorical and not an analytical sense. His use of the word evoked an image of the interconnections of social relationships but he did not go on to specify the properties of these interconnections which could be used to interpret social actions except at the abstract level of 'structure'. Perhaps more often than not the work 'network' when used in sociological contexts is used in this metaphorical way.... But the metaphorical use of the word, however common it is, should not prevent us from appreciating that it is possible to expand the metaphor into an analogy... and use the concept in more specific and defined ways." (J Clyde Mitchell. Social Networks in Urban Situations. Manchester, 1969, page 2).

C. Information, Communication and Transportation

"Urban networks are not isolated. Changes in information processing affect communication: new forms of communication provide alternatives for transportation; improved transportation networks all more frequent face-to-face communication; faster information processing allows analysis for improving transportation; and so on." (Editorial. Networks: information, communication and transportation. Ekistics, 35, 211, June 1973, page 318).

"In the contemporary world, with its vast networks of instantaneous communication, quick travel and rapid transport..." (Harold D. Lasswell. Second Conference on Environment and Society in Transition. New York. 1974).

The White House "on the assumption that the bill will pass, plans a wide network...of 600 businessmen... to be part of an elaborate network of government-industry relations." (New York Times, 13 May 1974).

D. Crime Networks

"Smith, 58, chairman of the Northern Economic Planning Council in 1965-70, masterminded a web of corruption"..." "Mr. Taylor said the corruption system was operated through Smith's network of public relations companies..."

E. Transnational Organizational Networks

"... we need to think in terms of the creation not of a single center, or a single world government that will some

day govern the nations of the world, but rather in terms of a self-regulatory network of transnational institutions, multiple institutions, a polycentric system. Such a transnational network can provide a higher degree of stability for the planet than the centralized model based on a single international governmental organization.... we must first recognize that the U.N. is only a tiny piece of a swiftly emerging transnational mosaic or network of institutions which are part of the new super-industrial system. This network consists of thousands of organizations and millions of individuals around the world in continually shifting relationships with one another." (Alvin Toffler. Hearings before the Senate Committee on Foreign Relations, 94th US Congress, 1st Session, 1975).

"The map of organizations or agencies that make up the society is, as it were, a sort of clear overlay against a page underneath it which represents the reality of the society... There's basically no social problem such that one can identify and control within a single system all the elements required in order to attack that problem. The result is that one is thrown back on the knitting together of elements in networks which are not controlled and where the network functions and the network roles become critical." (Donald Schon. What we can know about social change. BBC Listener, 1970).

F. Networks in the Social Sciences

"The abstract notion of a network is undoubtedly called to play a role in the social sciences comparable to the role played in physics by the concept of euclidean space and its generalizations. But the poverty of concepts and methods stands in dramatic contrast to the immense conceptual and methodological richness available for the study of physical spaces. A whole reticular imagery remains to be developed. At this time a network is understood to contain simply nodes and links and little else." (Paraphrase and translation of Francois Lorrain. Réseaux sociaux et Classifications sociales. Paris, Hermann, 1975).

Possible distinctions between "network" and "system"

1. Systems tend to require more information for their description than networks, since flows must be described as well as structural relationships.

2. Systems are described primarily with quantitative information (which is both difficult and costly to obtain and has a short useful life), whereas networks may be described with non-quantitative structural information (which is more readily available at lower cost and has a longer useful life).

3. Systems tend to have a unique (or ultimate) controller regulating the state of the system as a whole, whereas networks tend to have a plurality of controllers (if any), with a relatively high degree of autonomy. (In other words, systems tend to be centralized in some sense, whereas networks tend to be decentralized or polycentric).

4. Systems tend to be associated with imposed structures or patterns (even if limited to the choice of the system boundary), whereas networks tend to be associated with emergent structures or patterns.

5. Systems tend to have well-defined boundaries (even if they are open-systems) whereas the outer-limit (or fine detail) of a network is ill-defined and not of major significance to its description.

6. Systems tend to have well-defined, stable goals or functions, whereas networks, if they have any, may have ill-defined goals, a plurality of goals (possibly fairly incompatible), or may change goals relatively frequently.

7. Systems tend to have a more limited tolerance of changes to their environment, whereas networks tend to maintain a fair degree of invariance and coherence even in the event of highly turbulent transformations to their environment.

8. Societal system descriptions tend to be meaningful only at a macro-level to detached observers, whereas network descriptions retain their utility even when limited to the immediate environment of an involved participant at a particular node of the network.

9. Systems, and particularly their dynamics, tend to be difficult to represent, whereas complex networks can be represented with relative ease.

INDICATIVE LISTING OF TYPES OF NETWORKS

A. SOCIETAL NETWORKS (Deliberately developed)

1. Networks of Organizations and Groups

In which distinct organizations are linked together in networks which may include one or more of such types as the following:

- Government agencies
- Voluntary agencies
- Political groupings
- Communes
- Corporate enterprises
- Pressure/interest groups
- Community groups
- Spiritual communities

2. Institutional networks

In which the size and complexity of a particular institution, and the range of its many associated sub-units, makes it useful to perceive the institution itself as a network through which people, decisions, goods, funds, etc. may pass:

- Civil service (national)
- Diplomatic service
- Multinational corporation
- Criminal networks, rings, etc.
- Espionage networks
- Civil service (international
- Military service(s)
- Religious networks
- Police-informer networks, security networks
- Counter-espionage networks

3. Networks of Individuals

3.1 Specialist dealers (antique, art, book, etc..."the trade")
Professions (doctors, lawyers, architects, etc.)
Academic (philosophers, sociologists, etc... "invisible colleges")
Elites (moneyed, social, cultural, etc.)
Business/industry/commerce communities
Fraternal societies/"Old boy" networks

3.2 Secret societies
"Deviant" groups (drug users and pushers, homosexuals, vegetarians, etc.)

3.3 Inter-personal networks
Intimate networks

3.4 Intellectual influence networks (sciences)
Intellectual influence networks (letters)
Artistic influence networks
Innovation influence networks
Rumour diffusion networks

3.5 Collectors
Radio amateurs
Pen friends
Correspondence chess

3.6 Genealogical trees

4. Networks of Regulations

- Laws, treaties
- Bye-laws
- Standards
- Contracts, agreements
- Regulations (health, safety, etc.)
- Patents

5. Service networks of individuals

In which individuals are on-call or despatched, such that they may be perceived as constituting a network or as being constantly on the move between a network of possible locations:

- Maintenance serviceperson (telephone, electricity, machine, etc.)
- Freelance fashion models
- Secretaries (temporary)
- Police
- Ambulance
- Actors, entertainers ("the night-club circuit"
- Journalists
- Call girls
- Caterers

B. INANIMATE NETWORKS (deliberately constructed)

The following networks may be perceived in different ways, such as:

- by those planning or redesigning the networks in question;
- by those charting, mapping, describing or (re)presenting the networks for purposes of communication;
- by those operating the networks (despatchers, exchange controllers, etc.);
- by those whose job requires that they move constantly through a network (airline personnel, railway personnel, et
- by those who benefit from the existence of the network as a simple user of part of it (e.g. bus service passengers, etc.);
- by those who are in some way negatively affected by the existence or functioning of the network.

1. Transportation Networks

1.1 Pipelines (for oil, water, etc.)
Electrical grids

1.2 Railways (goods, passenger) - Airline networks
Subways - Bus networks

1.3 Truck delivery - Taxi (radio)
Police car (radio) - Merchant ship/tanker

2. Communication Networks

2.1 Telephone, telex - Data links (computer)
Cable - Wire services
Pneumatic tubes

2.2 Post

2.3 Data gathering (scientific) - Data gathering (militar
Data gathering (meteorological)

3. Transation Networks

Fund/payment/cheque clearing services
Foreign exchange (dealers)
Commodity exchanges (metal, agricultural products)
Stock exchanges

Mathematically based/oriented disciplines

A Topology
Graph theory
Lattice theory
Mathematical typology

B Systems analysis
Cybernetics
Operations research

C Transation analysis (Trade)
Input/Output analysis (Economics)
Cross-impact analysis

D Sociometry
Central place theory/Location analysis (geography)
Ekistics (related to urban networks)
Ecosystem analysis
Network analysis/synthesis (circuit design)
Citation analysis

E Synergetics (topology plus vectorial geometry)

Aids to handling networks

A PERT
CPM
GERT
Decision trees
Relevance trees

B Organization charts

C Network map design
a) Railway, bus, road, airline, etc.
b) Electronic circuits
c) Metabolic pathways
d) Flow charts
e) Block diagrams

D Computer-aided visual representation of networks (CRTs, graph-plotters)
a) computer aided design (air frame, machines, etc.)
b) computer aided design (buildings, factories, towns, etc.)
c) critical path networks on computer
d) display and analysis of complex molecules

E "Decision rooms"
a) War rooms
b) Corporate policy rooms
c) Power grid control rooms
d) Factory operations control rooms

F Pattern recognition

Games, Structured Learning and Strategy

A Team ball games (e.g. football, basketball)
In which the network of the players formal functional relationships in the team must adapt (with success) to the specific relationships constituted by the current state of the opposing side's network and to the network constituted by the actual and potential movements of the ball within the two inter-woven networks.

B Board games (e.g. chess, go)
In which the players seek to resolve to their own advantage the interactions between the networks of: the formal relationships between their own pieces (and those of the opponent), the positions they currently do or could occupy, and the network of optional move sequences.

C Games with moving craft (e.g. computer simulated dogfights and space warfare)
In which the players combine the skills required to handle the network situations of A and B (above).

D Military strategy
In which many situations like that in C are embedded in a resource allocation (logistic) network which may itself be modified in the light of the assessment of the network of optional change sequences within the relevant space-time framework.

E Programmed learning (e.g. on computer, or in special texts)
In which material is structured as a network such that the student is either taken on to new material or back through the network to whatever associated material is appropriate to reduce his uncertainty about the subject.

INDICATIVE RELATIONSHIPS BETWEEN FOCAL AND CONTEXTUAL TOPIC AREAS

| | | STRUCTURE PERCEIVED INTERNALLY | | | | STRUCTURE PERCEIVED EXTERNALLY | | PROCESS/SYSTEMS |
|---|---|---|---|---|---|---|---|---|
| | | "Involved Participants" | | "Professional Users" | | NETWORK | NETWORK | DESCRIPTION ANALYSIS MODELLING |
| | | Negatively Affected | Positively Affected | Moving Through | Operating Networks | MAPPING (RE)PRESENTATION | PLANNING (RE)DESIGN | |
| NATURAL/ EMERGENT STRUCTURE | Conceptual | VALUE/BELIEF STRUCTURES NATURAL-LANGUAGE STRUCTURES | | | | | | |
| | Biological | | | | | Plant/Animal Tissues; Food-Webs; Metabolic-Pathways | | |
| | Inanimate | | | | ← | Crystal-Lattice Complier-Molecules | | |
| | | | | | ← | Waterways | | |
| | | | | | ← | Ridge/Valley/ River Network | | |
| | Societal | | | | | Kinship-Structures Family-Networks Extended-Family-Network | | Sociometry Group-Dynamics |
| HUMAN CON STRUCTS | Societal | | ←→ | | ← | Networks of Individuals | ← | |
| | | | ←→ | | ← | Institutional Networks | ← | Social Systems Analysis/ Modelling |
| | | | ←→ | | ← | Networks of Organizations | ← | |
| | | | ←→ | | ← | Networks of Regulations | ← | |
| | Inanimate | | ←→ | | ← | Transaction - Networks | ← | Network Analysis |
| | | | ←→ | | ← | Transportation Networks | ← | Input/Output Analysis |
| | | | ←→ | | ← | Communication-Networks | ← | Transaction Analysis |
| | | | ←→ | | ← | Circuit-Diagrams | ← | |
| | Biological | | ←→ | | ← | Designed-Food-Webs | Genetic-Engineering; Resource Conserving-Syst. | Ecosystem Analysis Agricultural Product. Systems Analysis |
| | Conceptual | PHILOSOPHIES/DOCTRINES CATEGORY-SCHEMES ARTIFICIAL-LANGUAGES PLANS/STRATEGIES COMPUTER-FILE-ORGANIZATION CONCEPT-NETWORKS PROCEDURES/SCHEDULES | | | | | | |
| THEORETICAL CONSTRUCTS | | | | | | TOPOLOGY GRAPH-THEORY | OPERATIONS-RESEARCH CALCULUS CYBERNETICS SYSTEMS-ANALYSIS | |
| REPRESENTATION TECHNIQUES | | IMAGES PHOTOGRAPHS MODELS | | | | NETWORK -CHARTS | | CHARTS/TABLES/ GRAPH FLOW CHARTS |

From the Yearbook of World Problems and Human Potential, Brussels, Union of International Associations/Mankind 2000, 1976.

**APPENDIX 5**

# MATHEMATICAL ANALYSIS OF NETWORKS

The data collected together in the thirteen different sections of this publication has been deliberately organized in a manner which stresses the interrelationships between the entities within a section and between those in different sections (Each section is characterized by entities of a different type, and several types of relationship may exist between the same two entities) In effect therefore, the entities and relationships in each section constitute a network, possibly composed of many subnetworks. Similarly, since entities in each section may be linked to those in other sections, the whole is constituted by a system of thirteen interlinked networks in which the relationships have a limited number of distinct meanings. The entities and relationships are currently held in computer files in a form which should facilitate analysis of these networks It is hoped that the availability of data in this form will encourage the development of new types of analysis more appropriate to the structural complexity portrayed, especially since both the quantitative data and the mathematical functions representing the nature of particular relationships under different conditions (which are a precondition for the application of current methods of quantitative analysis of social systems), are absent and in most cases unavailable.

As Francois Lorrain notes (see references), the abstract notion of a network is undoubtedly called to play a role in the social sciences comparable to the role played in physics by the concept of euclidean space and its generalizations. But the poverty of concepts and methods which can currently be applied to the study of networks stands in dramatic contrast to the immense conceptual and methodological richness available for the study of physical spaces. A whole reticular imagery remains to be developed At this time a network is understood to contain simply nodes and links and little else. An attempt to define anything like a reticular variable results in very little This is not surprising, since to succeed would require the establishment of a general mathematical theory of networks which as yet has been little developed In contrast to this situation, consider the multitude of spatial variables which are available. coordinates, length, surface, volume, curves, classes of curves, classes of surfaces, parameters of curves, parameters of surfaces, and so on, and all these in a space of any number of dimensions and manifesting any type of curvature

**Social Networks**

The types of network which occur in the social sciences are of such a diverse nature that only a purely formal definition of this notion is of sufficient generality

1 The basis of a network is constituted by a certain set of points. In the social sciences these points may represent any or all of the following. individuals, groups, organizations, beliefs, roles, etc In this exercise they represent international organizations (A series), commodities (C series), intellectual disciplines (D series), industrial sectors (E series), human development concepts (H series), occupations (J series), integrative concepts (K series), multinational corporations (M series), world problems (P series), human diseases (Q series), international periodicals (S series), multinational treaties (T series), and human values (V series) Such points may represent the existence of entities at the present time, or they may represent the existence of entities at some past or future time (or such points may also be used to represent intervals of time)

2 The points in a data set may be linked by one or more kinds of relationship In this exercise three basic types of relationship are distinguished. (a) Simple relationship, namely A is related to B which implies that B is related to A, (b) Hierarchical relationship, namely A is a part of B which implies that B is in contextual relationship to A, (c) Functional relationship, namely A acts on B which implies that B is acted upon by A.

In the first case above a relationship is further defined by the types of entity between which it occurs, namely whether they are of the same type (of which there are 13), or whether they are of different types (giving a further 156 possible types of relationship) In the second and third case, a relationship is further defined by distinguishing the direction of the relationship, which is further developed in the third case by distinguishing several ways in which A can act upon B

**Analysis of Networks**

Classical mathematics, summarizing Francois Lorrain's remarks, is not able to handle complex structural features characteristic of social systems Organization is best depicted as a network. The mathematical theory of networks derives largely from certain branches of topology and abstract algebra rather than from analysis, which underlies classical mathematics The theory of graphs is often presented as a kind of general theory of networks with numerous possible applications in the social sciences. However, other than in the area of operations research, the theory of graphs has not proved itself to be very useful in sociology. The reason is probably that the theory has mainly been developed in the context of relatively limited problems in such a way that the results collected under the graph theory label, although numerous and of great interest, have little unity In addition, the theory rarely handles networks with several distinct types of relationships each with its own configuration of links It is precisely such networks which are of most interest in sociology. The theory also tends to exclude networks in which some of the points have links back to themselves when it is often just such networks which are important in representing social structures.

A final disadvantage of the theory of graphs is that it only offers a fairly limited number of means of global analysis of networks. It seriously neglects an important aspect of the study of any type of mathematical structure, namely the level of transformation relations between graphs. Because of its composition, a category possesses a richer structure than a simple graph, and it is therefore possible to define more rigorous and fruitful criteria of transformation (namely the concepts of function and functional reduction) In addition a set of points and a set of relations can be treated in their totality and simultaneously, in contrast to the methods of graph theory which considers individual paths between particular points in the graph In the universe of categories (the universe of objects and relationships), transformations between categories may also be considered as relationships within a category whose objects are themselves categories, and so on All this emerges from consideration of the global structure resulting from the manner of composition which relates the relationships themselves, thus providing a dialectic of levels of structure and a new imagery of networks. At all levels of this universe, the functional relationships between categories play a central role. They are the fundamental instruments which may be used in the exploration of structural complexity and the tools for extraction of information in global studies

**Use of graph theory methods**

Despite the limitations noted above, graph theory methods have been applied to the analysis of social structures although such applications are not very common (see references below)

The image of a 'network or web' of problems (or organizations, etc) to represent a complexset of interrelationships is a fairly familiar one. This use of 'network', however, is purely metaphorical and is very different from the notion of a network of concepts as a specific set of linkages among a defined set of concepts, with the additional property that the characteristics of these linkages as a whole may be used to interpret the semantic significance of the concepts involved

**Some features of graphs** Using graph theory, a number of characteristics of networks can be determined Points 1 to 3 below are concerned with the shape of the network, 4 to 8 with interactions within the network

1 **Centrality** A measure (in topological not quantitative terms) of the extent to which a given entity (e g. a problem) is directly or indirectly 'related' via links to other entities (i e , the extent to which it is 'distant' from another entity) One can speak of a 'key' problem or of an organization being 'central' to the concerns of a particular complex It may also be considered a measure of the degree of 'isolation' of the entity. A systematic analysis of the centrality of entities in a network could indicate where new entities are necessary to bridge gaps and link isolated domains

2 **Coherence** A measure of the degree of 'interconnectedness' or 'density' of a group of entities This may be considered as the degree to

which a system of problems is 'complete' Differences in density would reflect the tendency for more highly coherent problem systems to appear more self-reinforcing in comparison to less organized parts of the network In some respects this is an indication of the degree of 'development' of a problem system

3 **Range** Some entities are directly related to many other entities, others to very few. The range of an entity is a measure of the number of other entities to which it is directly related. Range could be considered an indication of the 'vulnerability' of a problem to the extent that a high range problem would be less vulnerable to attack than a low range problem, since it has more relationships anchoring it to its problem environment and preserving it in existence High range points are therefore either key points in resistance to problem change or else key points in terms of which orderly change can be introduced.

4 **Content** The 'content' of a relationship between entities is the nature or reason for existence of that relationship Simple graphs have only one link between any two entities; multigraphs have two or more links, each of different content

5 **Directedness** A relationship between two entities may have some 'direction' (i.e., A to B, or B to A) There may be several types of directedness Two types are important for this project: A is a subelement of B (relationship codes 50/51), A acts on B (relationship codes 60/61, 62/63). In a multigraph, one link may point from A to B and the other from B to A

6 **Durability** A measure of the period over which a certain relationship between entities is activated and used At one extreme, there are the links activated only on a 'one-shot' basis (e.g. a single crisis), at the other there are links, and sets of links, which are considered stable over centuries (e g between the more permanent problems)

7 **Intensity** A measure of the strength of the link or bond between two entities. Two problems may be said to be 'strongly bound together' In some cases, the intensity is a measure of the amount of the 'flow' or 'transaction' between the entities. The link from A to B may be strong, and that from B to A, weak.

8 **Frequency** A link between two entities may only be established intermittently

9 **Rearrangeability and blocking** A connecting network is an arrangement of entitites and relationships allowing a certain set of entities to be connected together in various possible combinations. Two suggestive properties of such networks, which are extensively analyzed in telephone communications, are· (a) rearrangeability (a network is rearrangeable, if alternative paths can be found to link any pair of entities by rearranging the links between other entities); (b) blocking (a network is in a blocking state if some pair of entities cannot be connected).

**Implications of artificial intelligence research**

In considering the possibility of analyzing networks of problems (organizations, concepts, etc), it is important to benefit as much as possible from related work on artificial intelligence, and possibly pattern recognition Artificial intelligence projects to simulate human personality or belief systems have had to develop mathematical techniques and computer programmes which can handle and interrelate entitites such as concepts and propositions, some of which may be positively or negatively loaded to represent positive values and perceived problems (the credibility and importance of a belief in a network, and the intensity with which it is held, may also be indicated). Clearly the objective of such projects is not achieved once a simple inventory of entities can be examined, even if it is highly structured in the form of a thesaurus Of particular interest is the work on 'dialogues' with such belief systems, some of which are established over a period by extensive interviews with individuals and others which are specially constructed to simulate paranoia, for example. (see references) Presumably it would be possible to conduct somewhat similar dialogues with the collective beliefs constituted by problem/value netwroks such as might be developed during the course of this project.

**Conclusion**

Despite the available techniques noted above, and others which have been applied to non-social networks (see the journal *Networks*, for example), much would seem to remain to be accomplished, as Francois Lorrain's remarks indicated, in order to grasp networks in their totality

The question is what it would be useful to know about networks at this time What indicators would it be useful to attach to individual problems (organizations, etc ) to indicate the characteristics of their relationship to the network(s) in which they are embedded? What similar indicators would be useful in describing the relationships between relatively dense networks and the larger network in which they themselves are embedded? What sort of concept about networks need to be embodied in a **network vocabulary** so that such matters can be discussed intelligently and unambiguously in public debate? In other words, what are the elements of an adequate vocabulary of structure and in what disciplines has the basis for such a vocabulary already been established· chemistry crystallography, architecture, design in general, etc? What can be learnt from biologists about the growth and development of the many reticular structures they encounter (e.g radiolaria)? More interesting perhaps, in which occupations do some individuals develop a special (instinctive or intuitive) sensitivity to the structural and dynamic characteristics of the networks with which , or within which, they work: airline pilots, urban bus drivers, electricity grid controllers, counter-espionage directors, factory process controllers, computer-based data network designer/controllers, telephone exchange designer/controllers, institutional fund controllers, etc? What do such people say, or want to say, about their networks? Why has the term 'networking' suddenly sprung into common use and consequently what could 'to network' mean? It is questionable whether any adequate organizational response (a **network strategy**) to the world problem complex can be elaborated until such rich experience is collected together and matched to an elaborated, mathematically-based concept structure, and an associated vocabulary (see Appendix 10) A conceptual quantum jump is required to grasp problem (and other organized) structures in their totality and be able to communicate such insights

It is hoped that the availability of the data in this publication will help to stimulate such fresh thinking on the conceptual containment of societal networks

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APPENDIX 5

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**APPENDIX 7**

## NETWORK MAP PRODUCTION

**Acceptability of network maps**It is now considered quite acceptable in many major cities to print and make available to the general public (often on notice boards or in tourist literature) various schematic maps: the subway (underground, or metro) network, the urban bus network, and the suburban railroad network. Travellers are also accustomed to exposure to documents showing the airline network. Other kinds of network are mapped for the benefit of workers in specialized sectors (e.g. oil pipeline networks, electricity distribution networks, telephone networks, military communication networks, goods distribution networks, etc.). The most complex map of this type would seem to be that used to summarize (on a surface 100 x 132 cm) the relationships between over 1000 biochemical compounds involved in metabolism (See: Gerhard Michal. Biochemical Pathways. Mannheim, Boehringer Mannheim GmbH, 1974, also, but less complex: D. E. Nicholson. Metabolic Pathways. Colnbrook, England, Koch-Light Laboratories, 1974).

The point is that people are now very familiar with such maps in one form or another and use them, like road maps, to organize their thinking about the movement of themselves or items with which they are concerned between distant points embedded in a complex network. No such network maps are currently available to show the relationships between distant points representing particular features of the social system. As a result thinking about the social system and its problems is somewhat chaotic, as would be any discussion about travel in the absence of adequate maps to provide the necessary frameworks for such discussion.

**Reasons for the lack of societal network maps**

1. There is much confusion concerning the kinds of entities that can be distinguished in the social system, due to overlapping systems of categories, needs, and the maze of associated terminologies.
2. Where clarity emerges, it is usually in relation to one particular entity (e.g. one holding company and its network of subsidiaries, or one government agency and its associated bodies); any maps produced then have that body as the central reference point.
3. Much of the required information is scattered through a variety of reference books and no research has justified its systematic organization.
4. Systematic sociological research in the past inverts the focus so that, for example, instead of determining how many organizations (problems, etc.) there are in a sample in order to determine the number per capita, the mean number of personal relationships to such entities is determined on a per capita basis, so that there is no means of determining how many distinct entities there are to which the relationships are established.
5. Where such information is collected it is often considered secret because of its political or economic significance. Examples are (a) the collection of data on organizations in every country by the civil or military intelligence units, and (b) the secrecy associated with the subsidiaries owned by a major (multinational) corporation at any one time and their interrelationships.
6. Where the data can be collected, and there is a strong case for doing so, there is often reluctance to do so because of the problems of data handling. This is best seen in the (non-societal) case of mapping ecosystem food webs in which animal species are embedded. There is a multiplicity of inter-specific 'food chains', together with many branches and cross-connections among food chains making a structure of interactions called 'food webs'. The complexity of these food webs is such that no one has yet worked out the complete pattern of food relationships and interactions in any natural community. The relationships between 50 species in a given community results in a diagram 'so suff of lines that it is difficult to follow' and this only represents one quarter of the 210 known species in a 'simple' community. (David Pimental. Complexity of ecological systems and problems in their study and management. In: K. E. F. Webb (Ed) Systems Analysis in Ecology. New York, Academic, 1966, pp15-35).
7. Where the research has been done, there is a reluctance to produce maps because of the tiresome, time-consuming and often costly nature of the task of doing so (also discussed in Appendix 6), particularly when the networks are complicated.

**Psycho-social significance of maps: a parallel**

The current ability to map the societal system may be usefully compared to that of the European geographical mapping ability during the Middle Ages and earlier. The changing psycho-social significance and status of maps, since such early times, provides many clues for understanding the present situation. Maps in that period were often closely guarded secrets, for military and economic reasons. And just as the understanding in Europe of non-European continents was very limited at that time, so today there are only a few well-known problem areas (such as population, food, peace, etc.). Each such territory (or 'feudal state') is more or less poorly controlled by a few major organizations (the 'cities') with a few well-established links between them (the 'roads' or 'rivers'). The relations between these feudal states are the limit of concern. Few people travel long distances and when they do, in the absence of readily available maps, they use 'experts' to guide them from point to point. Other continents are only vaguely known (and are widely held to be populated by mythical monsters). Each group is content with artistic or impressionistic two-dimensional maps centred on its own organization (or field of concern), confidently held to be the prime mover in the social system as perceived from that point of reference. The significance of any three-dimensional representation is not recognized and a flat-earth perspective prevails.

Under such conditions, it is easy to understand the psychological and communication difficulties which make it impossible to achieve any general galvanization of political will in response to world problems. Each sector is content with its own sketchy local map (if any is held to be required) of the problem environment, and there is little concern for whether such local maps mesh together with those of neighbouring territories or into a general map of the region. Communication therefore frequently breaks down and moments of solidarity are soon forgotten. Warring between feudal territories is common. The state called 'energy', clashes with that called 'environment'. Alliances are formed and each state has imperialistic ambitions: 'development' wants to incorporate 'environment', 'environment' lays claim to the territory of 'development', and all are claimed by the territory called 'peace'. Lacking maps, assemblies of individuals and groups from different problem territories are pathetic. The people from 'heavy rainfall' areas cannot understand the constant harping on water by people from 'desert' areas; the people from 'arctic' areas cannot relate meaningfully to those from 'tropical' zones.

The history of the evolution of geographical perceptions, and the tools that have been required to move humanity towards a global perception, indicate the kinds of difficulty which have to be faced. (The much-used NASA photograph of Earth from space is only significant as a symbol because people know that they can relate its features to the map of the world in their own atlas in order to be able to locate their home town, for which they also have a detailed local map, to which they can relate their personally acquired knowledge.) Local maps are needed which mesh into global maps, so that each can see his place in any world problem strategy and so that global decision-making can relate to the tactical problems of groups as perceived in each community.

Problem maps (bound together into 'atlases') are needed to help individuals see and appreciate the relationships, distances and differences between problem territories. And it should be possible to relate these to organization (and other) maps, just as any atlas has contour maps, climatic maps and political maps of the same region. Individuals, whether students, executives, researchers, or policy makers, have at least as much need for such visual devices to orient themselves in the social system as they have for road and other currently available maps.

Hopefully it will be possible to reach a stage at which such maps can be produced as standard conference documentation as a means of providing background documentation for debates, and in order to sharpening the focus of debate. Clearly the debate itself should lead to proposals for the amendment of such maps (as a result of the recognition of new issues, relationships between problems, proposals for organizations or programmes, or new relationships between organizations, etc.). New versions of such maps, or hypothetical maps (e.g. of organizational systems) could be fed into later sessions of the same meeting or used as one form of summary of the achievements of the meeting.

**Production of network maps**

Once the information on societal entities is held on computer it becomes possible to overcome many of the obstacles to map production noted above (and in Appendix 6) Computers are currently used to plot out electronic circuit diagrams and other types of network onto large charts The computer programmes handle the tedious problem of designing such charts, including the use of appropriate colours to distinguish between different features of the network (or networks) on the same chart. (Artists, designers and communications psychologists can also introduce an aesthetic component to facilitate comprehansion).This approach has the considerable advantage that different designs (based on the same data) may be tried or used for different purposes Some designs may be highly simplified, others may be very complex New maps can be easily produced if the original data is modified The data base used may be the same as that used for interactive studies of the network (see Appendix 6) so that both approaches may be integrated under the control of a researcher

However, although the computer programmes exist for the production of two-dimensional maps, there are difficulties still to be overcome in the representation of three (or n) dimensional networks on a two-dimensional surface, if such complex representations are necessary. Some of these mathematical and associated problems (of projections) have been examined by geographers interested in producing a more accurate representation of the spherical Earth on a map Experiments have been made with a number of alternatives which each have their advantages The data collected together on computer for this publication should encourage and facilitate similar experiments in societal network map production

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**APPENDIX 10**

## NETWORK ORGANIZATIONAL STRATEGY

The conventional approach to any problem situation is to elaborate a strategy But as this publication attempts to show, the number, variety and interrelationships of the problems are such that it is legitimate to question whether any conventional strategy could be even partly adequate A fundamental difficulty today is the predeliction for simplistic hierarchical representation of the interrelationships between concepts, between organizations, and between problems This is so despite constant exposure to evidence that these hierarchies do not contain the complexity with which society has to deal

It is for this reason that it is questionable whether conventional strategy, which is based on the assumption that it can be formulated and administered through a hierarchical chain of authority, can respond to the needs of the time. Neither a hierarchical organization nor a hierarchy of concepts can handle a network of environmental problems, for example, without leaving many dangerous gaps through which unforeseen problems may emerge and be uncontainable. It is rather like trying to use 18th century (redcoat) military strategy to fight guerillas The redcoat military hierarchy and mode of warfare is completely outmanoevered by guerilla network activity (An even more uncomfortable parallel may be that of the admirable attempt of the Polish cavalry to contain a tank invasion in 1939 )

The elements of the strategic problem at this time include.

(a) a vast and largely uncomprehended network of perceived problems and problem systems, on which no single body has (or possibly could have) adequate information,

(b) a vast and fragmented network of conceptual tools and knowledge resources, which is not (and possibly could not be) comprehended by any single body,

(c) a vast and largely uncomprehended network of agencies, organizations, groups and active individuals spanning every conceivable human interest and extending from the community level to the international level and on which no single body has (or possibly could or should have) adequate information

These networks and others, are not static structures They are rapidly changing, growing and evolving in response to pressures, tensions, needs and aspirations perceived in very different parts of the social system These networks, and their component subnetworks, are not controlled or controllable by any single body, if only because the complexity cannot be handled by any single body or group of bodies

The strategic problem therefore is how to ensure that the appropriate organizational resources emerge, and are adequately supported andprovided with appropriate conceptual tools, in response to emerging problem complexes But it would seem that this must be achieved **without** organizing and planning such organized response -for to the extent that any part of the network is so organized, other parts will develop (and probably should develop) which favour alternative approaches

The challenge is therefore to develop the meaning and constraints of what may be termed a **network strategy** This is an approach which **facilitates** or catalyzes (rather than organizes) the emergence, growth, development adaptation, and galvanization of organizational networks in response to problem networks, in the light of the values perceived at each particular part of the social system

To the point that such values may not be the 'right' values, it is only possible to respond that the challenge is to use the dynamics of the social system to heal itself, to compensate for inadequate values (by the educational action of group on group), and thus to mature the social system The strategic problem is to ensure that all possible resources bring themselves to bear on the perceived problems, but without introducing at the highest level any element of organizational imperialism, or, in its absence, what might be called conceptual imperialism (or even fascism) The most enlightened developed-country value, may well be an inappropriate straitjacket in a developing country's cultural context Any such strategic simplification can therefore only lead to alienation possibly apathy, and of course even to compensatory action The degree of organization introduced by a body thus defines the level at which that body is competent to operate -the greater the degree of programme control and organization, the more restricted the scope of its possible effective operation The challenge is to speed up some of the dynamics of the social system so that organizational, conceptual, and value inadequacies become more rapidly evident in order that more appropriate substitutes may be evolved This is a learning process essential at every point in the social system.

To the point that any such strategy needs to be coordinated, the response can only be that at this time all that is possible (or even desirable) is a form of augmented auto-coordination within organizations and organization networks The challenge is to find the right means of facilitating whatever auto-coordination is possible, recognizing that to the extent that the degree of coordination is considered inadequate by one part of the network, it will attempt to elaborate tighter forms of coordination, whatever the views of the other (possibly alienated) parts for which a different approach may be successful. (It is interesting to note that some of the more recently created United Nations structures place great emphasis on the notion of a network and de-emphasize the notion of central organization -the United Nations University, the UN Environment Programme's information service, the UNESCO/ICSU UNISIST system)

The greatest unrecognized resource at this time is the vast uncharted network of organizations of every kind, with every kind of preoccupation and with every degree of effectiveness It is not known either what this network could achieve if its processes were facilitated, or what is the nature of its synergistic potential Just as there is a Third World of underdeveloped countries constituting the greater proportion of the world's population, so there is a Third World of underdeveloped organizations which could (and do in part) constitute the most vital resource for the solution of world problems

At the close of the First United Nations Development Decade (1960-1969), the Secretary-General of UNCTAD stressed the importance of the creation of 'political will' to avoid a Second Decade 'of even deeper frustration than the first one' (TD/96) Following remedial action by the UN Office of Public Information, in the UN Secretary-General's review and appraisal of the 'Dissemination of Information and Mobilization of Public Opinion Relative to Problems of Development' (E/5358, 21 May 1973) it is noted that '**the state of public opinion on matters of development, particularly in the industrialized countries, is generally less favourable today than it has been in the past**' The report notes 'it would probably be unfair to conclude that a sudden callousness had overcome public opinion in the developed countries It is more like **a closing of the gates to a pattern of generalizations perceived as outworn by over-use**' Over the same period the problem situation has worsened considerably

It would seem that there is a case for considering an alternative approach to facilitating the response of the organizational network to the world problem complex -in order to avoid a Third United Nations Development Decade of even deeper frustration than the second

One facilitative technique is to make accurate, readily comprehensible maps (see Appendix 7) widely available so that new structures and their auto-coordination can emerge wherever possible Hopefully this publication will stimulate further thinking on the meaning of a network strategy in such a context, in place of continued faith in the planning and action of a limited number of organizations (which have proved unable to contain the problems of the recent past and are therefore unlikely to be able to contain the more complex problems which are emerging).

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