Computer Networks and Simulation II
S. Schoemaker (ed.)

GLOSAS PROJECT
(GLObal Systems Analysis and Simulation)

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GLOSAS Project proposes the development of an international peace gaming of energy, resources and environmental systems to provide decision-makers with comprehensive information. This gaming will utilize integratively distributed computer simulation, database management and conferencing systems on global public packet-switching communication networks. The complementary models written by experts of various disciplines and countries, with their preferred simulation languages, methodologies and geographically dispersed dissimilar computers will be interfaced and executed interactively and cooperatively, as parts of the total simulation required.

I. INTRODUCTION

Mankind now stands at the brink of an unprecedented crisis as a result of the adverse effects stemming from the depletion of limited resources and the abuse of the environment. Whether man will endure and continue to prosper is a question whose answer lies in the skill with which we make policy-decisions today. As a consequence of the increasingly complex nature of our modern life, we have witnessed the development of powerful economic, political and social factors whose impacts upon many facets of society are of increasing scale and longer duration. In this situation, the effects of ill-planned policies have become more difficult to reverse; and our ability to make better decisions is inhibited by factors which often lie beyond the control of our traditional institutions and methods. Seen in these circumstances, the need to make the best possible decisions today is obvious if we wish to avoid the hardships of war, starvation, economic panics, and epidemics, with a continuing progress toward a better world.

Significant interdependences exist today among the highly developed economies of the United States, Japan and Western Europe. These countries, because of their size, significantly affect one another by their national policies and their competitive bidding for limited resources of energy, food and other resources. They have a mutual interest in evaluating before their implementation the affects of major policy-decisions of individual countries and groups of countries on their internal economic structures and on the flow of trade in goods and hard currencies among their economies.

Today, important technical data are being rapidly synthesized into a comprehensive economic basis for evaluating effects of possible policy-decisions on resource use, waste discharges, capital availability, production costs and trade flows. This basis may be used to evaluate how those policies will affect employment, output and income within a country, as well as the trade flows of goods and currencies among countries. Modern computer technology, which makes these computations possible based on vast amounts of information, can also be used to transmit via telecommunication this information quickly and cheaply among representatives of all of the participating countries. This paper will discuss these technologies and their application to large-scale distributed computer simulation system.

II. NEW METHODOLOGIES FOR GLOBAL POLICY ANALYSIS

1. Distributed Processing

1.1 Introduction

Advances in the various technologies of mini-computers and communications made the pursuit of economy-of-scale available through centralization of data processing a universal practice. However, a growing number of users are discovering complexity-of-scale limitations as they try to achieve the economy-of-scale advantages through centralization (3). Three basic functions necessary to configure information networks are the following.

(1) Distributed Network Processing

--- Ability to move information between various locations (nodes) within a network and includes:

(a) Control of interface between terminal devices and the network.

(b) Control of interface between the various information processors, database processors, and the network.

(c) Control of information movement between terminals and information processors, terminals and other terminals, information processor to information processor, and potentially, between database processors and all of the preceding.

With the advent of distributed computer node network, or the so-called value added network (VAN), the distribution of network processing was made possible and consequently the network processing was separated from the functions of information and data-base processing, which will be described below. The networks' main function is to provide a path and necessary control logic for the interaction between network information processing and database processing resources -- and to provide for efficient access of these resources by the various network users. The network processing function is becoming almost entirely application independent, and also now fast becoming a utility -- in the sense of a gas or electric utility.

(2) Distributed Information Processing

--- Manipulation of information to accommodate the needs of dispersed users, includes:

(a) Assembly and/or compilation of various user application programs.

(b) Execution and control of application programs.

(c) Production of output in various user specified media and formats.

Migration of more application programs into the on-line environment frequently results in a similar migration of associated database(s). The growing availability of data communications facilities, increased terminal usage and dependence on online databases capable of supporting heavy access loads will soon produce an increasingly visible conflict. In most offerings today, the information and database processing functions reside in and share a single computer, usually the information processor. The conflict occurs as both functions compete for a single set of resources -- such as memory space, processor time, channel time. In a site with heavy information and database processing requirements, successful resolution of the conflict is not always possible -- no matter how clever the scheduling and allocation algorithm.

This and the previously mentioned complexity-of-scale inherent in very large on-line databases (whether centralized or distributed) suggests that a second separation-of-function between information processing and database processing functions may be in order. Similar to the separation of network processing from the other two processing functions made possible with the network of distributed mini-computer communication switching nodes, the separation of information processing from database processing function may be made possible by the network of distributed information processing.

Link protocols among mini-computer switching nodes for network processing, while useful for masking differences and permitting intersection between terminal devices, do not provide adequate logical control levels for the intersection between coequal information and database processing resources. Higher protocol levels that will facilitate such intersections efficiently are being developed. The network processing function has been presented as a utility to the information and database processing functions.

Distributed network processing and distributed database processing are support functions to distributed information and applications processing. The distributed computer simulation system (DCSS), which will be described later, is the application of this distributed information processing capability to application programs, particularly of simulation activities. The system enables a user to interface component sub-models written in various simulation languages and which reside in dissimilar computers. These sub-models can then be executed as parts of the total simulation required, interactively, cooperatively and simultaneously in computer-to-computer conversational modes via the global public VAN.

(3) Distributed Database Processing

--- Ability to store potentially large amounts of information in one or more forms available for access by the network and its users. It includes:

(a) Generation of the database(s) in the appropriate form(s).

(b) Providing efficient access to the database.

(c) Maintenance and update of database integrity and consistency, including accuracy, restart/recovery, and data protection and security considerations.

A major advantage of the resource-sharing potential provided by totally distributed configurations is that information or database processing loads can be distributed uniformly (in theory) across currently available network resources. Application program distribution of this kind leads directly to the subject of distributing the database(s) associated with and accessed by them.

It appears logical to place the database elements, usually accessed by the application process at a particular location, under control of the database management logic resident at the location. Similarly, other database elements would be configured at other locations. Known as a partitioned database, this configuration has no single location within a network of this design that maintains a complete copy of the entire database.

By separating the database function and placing it in an essentially freestanding database processor, certain benefits can be achieved. For example, each of the three functions resides and executes in separate processors optimally designed for that function. The information and database processing functions execute more efficiently due to the elimination of complex scheduling algorithm overhead. In some cases, the separation of information processing from database processing may be considered as a means of alleviating the increasing density of data communications facilities surrounding centralized configuration.

(4) Summary

Motivations behind the design of distributed network, information and database processing functions are many -- ranging from increased throughput, decreased response times, economic advantages, and the realization that centralization may be difficult, if not impossible, due to complexity-of-scale problems. The separation-of-function philosophy will increase considerably the ability to fit the solution (network resources) to the problem (user requirements). The process is enhanced by the new found ability to define a network as a logical set of interrelated functions, each of which becomes a smaller, more manageable piece of the whole.

Frequently, existing autonomous information processing resources located at geographically distant sites and configured with different manufacturers' offerings are to be connected. Since they most likely will be physically and logically different, an adequate set of protocols must be developed for the distributed database processors to mask these differences and allow interaction -- particularly at the higher, user-visible levels. Distributed information and database processing may well be accomplished with higher level protocols and virtual network file system which will be described later.

2. Global Public Computer Communication Network

2.1 U.S. Public VANS

Dissimilar computers located at dispersed locations are being connected by telecommunication lines to form distributed, packet-switched data communication networks and these so-called value added networks (VANs) have been in operation in the United States. Most typical is ARPANET, controlled by the Advanced Research Projects Agency of the Department of Defense (49). Commercial versions, such as TELENET and TYMNET, have begun services several years ago (6, 24, 52, 70, 71). (Figure 1).

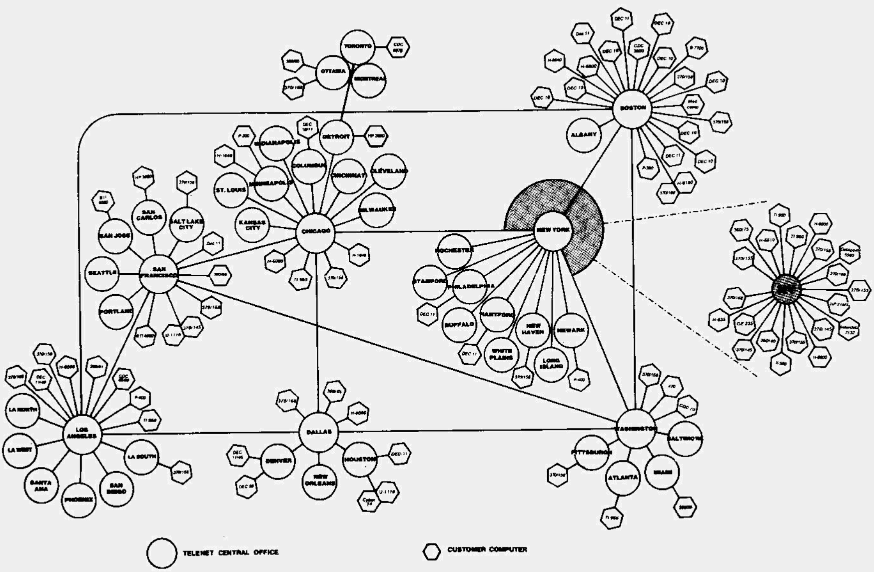
Packet-switching networks are dependent on minicomputer network controllers interconnected by high-speed transmission facilities. The minicomputers have been programmed to perform sophisticated switching, interfacing, and error-control functions. Data enter the network through local minicomputers where they are subdivided into "packets", each containing a small portion of the data, the destination address and error control information.

Each packet is routed individually through the network over the optimum (least delay) path existing at the moment of transmission. At the destination, packets are reassembled into their original order by the receiving minicomputer and are delivered to the addressee. No physical end-to-end connection is created between sender and receiver. Rather, a "virtual" connection is established. But as perceived by the users, transmission is essentially instantaneous. The network derives its effectiveness from its ability to optimize its handling of transmissions at far more instances than would otherwise be if the pattern of connections was fixed for the entire duration of a message. Through powerful error-detection methods, qualitative defects effectively disappear. Also, because of the extremely efficient sharing of the transmission facilities, the cost to the user can be significantly reduced to permit interactive communications.

Figure 1

TELENET LOGICAL MAP

November 1976



2.2 CSNET

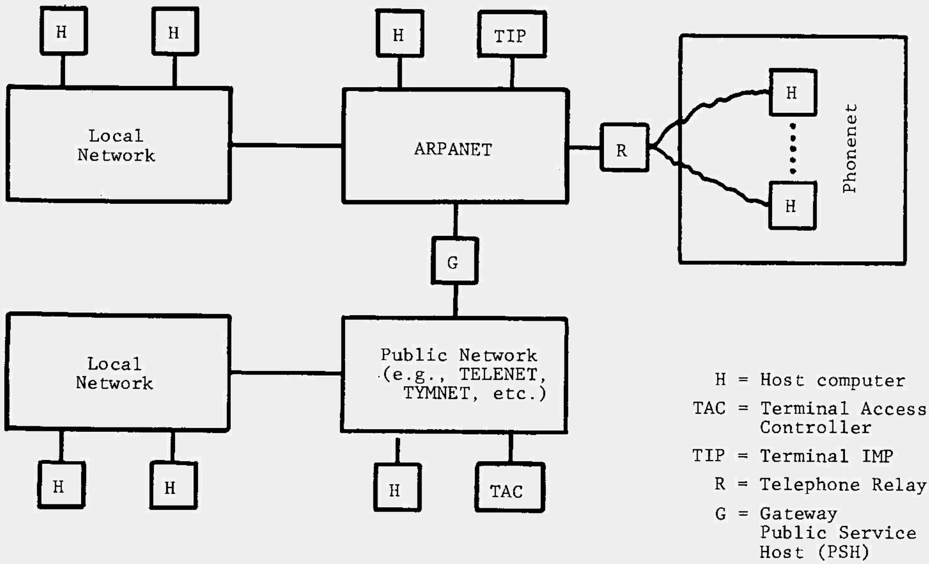
The Computer Science Research Network (CSNET), which is funded by The U.S. National Science Foundation since January of 1981, is a cooperative effort of computer scientists to establish a computer-based communications network which will interconnect computer science research groups in universities, industry and government in the United States. It is a national resource, supporting a broad spectrum of activities (60). Based on recent advances in computer network technology, including international protocol standards and the availability of commercial packet networks, CSNET will provide a feasible means for collaborative work at the forefront of computer science research by improving communication and by promoting the sharing of research tools. All hardware specifications and software developed through use of the network will be in the public domain.

CSNET is a logical network linking hosts on a number of other computer communication networks including ARPANET and public networks such as TELENET and TYMNET. CSNET will evolve by adoption of new technology as it becomes available and hence will offer continuing state-of-the-art computer communications services to the computer science research community. As new public networks are established, CSNET will expand to accommodate hosts that are connected to them. Gateways will connect the component networks so that communication between any two CSNET hosts will be possible by the use of a common addressing method and a uniform protocol architecture. For CSNET hosts that are not directly connected to existing networks, a telephone-based memo relay system called "PhoneNet" will extend CSNET interconnection to all who desire it. If neither PhoneNet nor public network links can be justified for a host, access for individuals may be via a so-called Public Service Host (PSH) (Figure 2, (60)) which will operate in the mode of a time-sharing utility. The PSH will provide routing and directory services, and access to CSNET via local public network dial-in ports, for researchers without a local CSNET host and away from their home institutions.

Communications services to be provided include message services, file transfer and interactive terminal access to remote systems and databases. Message service permits rapid exchange of messages or documents from one researcher to another.

Figure 2

U.S. CSNET Architecture



2.3 Global Computer Network

Up to the present time, however, the computer user is deterred from engaging in overseas data communications by a number of constraints, chief among these reasons are the low quality and high cost of existing international data communication services. The public VAN for international communications will overcome these dificulties with the use of powerful error-detection methods and the inherent efficiency of packet-switching.

The U.S. public VANs enable efficient and convenient data communications among terminals and computers and have now been extended to more than 35 major overseas countries and regions to form global public VANs. (See Figure 3 for the access to host computers of the U.S. VANs from overseas countries.) Those countries and regions are:

Operational (April, 1982):

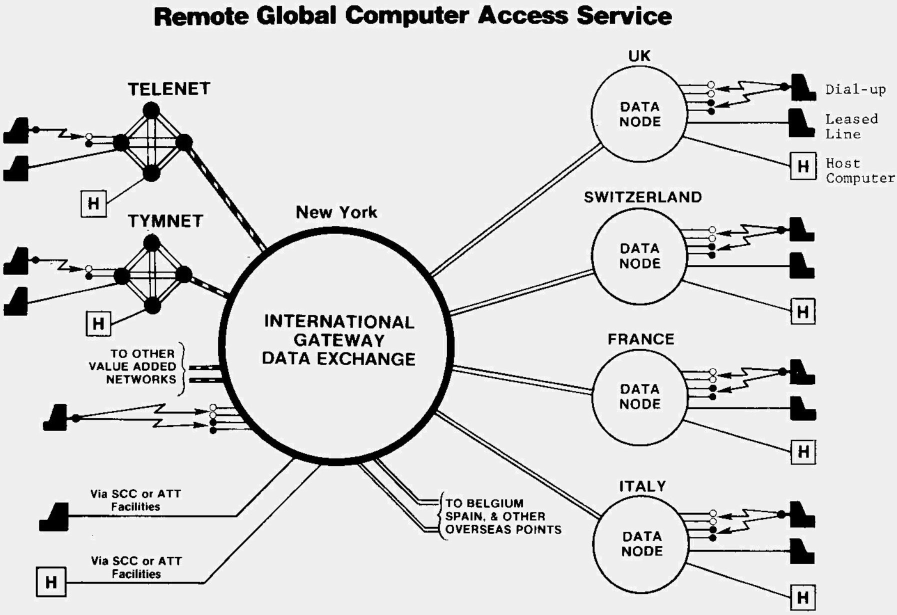
Alaska	Italy
Argentina	*Japan <u>(VENUS-P & DDX-PS)</u>
Australia	Korea (scheduled to start soon)
Austria	Kuwait (via Bahrein)
*Bahrein	Luxembourg
*Barbados	Mexico
Belgium	The Netherland <u>(DN1)</u>
Burmuda	New Zealand
Brazil (scheduled to start soon)	Norway
Canada <u>(DATAPAC)</u>	The Philippines
Chili	Portugal
#Colombia	Puerto Rico
Denmark	Qatar (via Bahrein)
Dominican Republic	*Saudi Arabia (via Bahrein)
Europe <u>(EURONET)</u>	Singapore
Finland	#South Africa
France <u>(TRANSPAC)</u>	Spain <u>(RETD)</u>
French Antilles (Guadeloupe and Martinique)	Sweden <u>(X.25 domestic VAN)</u>
Germany (West) <u>(DATEX-P)</u>	Switzerland
Hawaii	*Taiwan
Hong Kong	United Arab Emirates (Dubai and Abu Dhabi)
Ireland	The United Kingdom <u>(PSS)</u>
Israel	#Venezuela

Here, the country with the afixed sign has only one-way linkage with the U.S. so that only U.S. host computers of TELENET and TYMNET can be accessed from the country. Other countries have a two-way, high speed linkage with the U.S. in such a way that a host computer in the country can be accessed from the U.S.. The underlined networks are supplied by the national (or regional) carriers.

The U.S. public VANs have also been interfaced with the international telex networks of ITT Worldcom and RCA Globcom so that any host computers of the U.S. public VANs can also be utilized from almost all countries in the world without having to set up a permanent account with the communication administration in each country. The country with (#) sign can access the U.S. public VANs via those telex networks or via long distance phone call to the VAN switching node of the nearest country.

The implementation of international packet-switching facilities adopts a standard interface protocol for the connection of users' host computers to public VANs. This protocol also forms the basis for the interconnection of public VANs across national boundaries. Thanks to the advent of the VANs in the U.S., and also to the efforts of the U.S. Federal Communications Commission (FCC) in deregulating data-transmission, the interconnection of dissimilar computers located in various parts of the world will soon become a reality, thereby enabling utilization of a computer in a country from any other countries. Some of these countries are now vigorously organizing and interfacing their national public VANs, such as those indicated above, and EURONET in Europe, DDX-PS (domestic) and VENUS (overseas) in Japan (9, 73), and Israel, Mexico, Sweden, etc.. It is believed that their interconnection into multinational networks could follow. Incidentally, about 20 U.S. domestic, international and overseas public/private VANs have already been interconnected with ARPANET and TELENET, respectively, and the number is growing rapidly.

Figure 3



Interconnection of those networks across national boundaries enables substantially to strengthen multi-national educational and research projects engaged in collaboratively by geographically dispersed research workers, heretofore impractical due to unsuitable overseas communication facilities.

In order to achieve interactive simulation with a distributed simulation system among the computers geographically located in Japan and the United States, it is necessary to construct a global computer network between the two countries via satellite telecommunication. International Computer Access Service (ICAS), the extensions of TELENET and TYMNET to Japan, has been in operation since September, 1980. VENUS, which will be independent from ICAS but to be interfaced with the U.S. VANs, will also be interfaced with DDX-PS in the future, enabling computer (in Japan)-to-computer (in the U.S.) conversation. See Figure 4 for the proposed establishments of Japanese domestic public VANs and of a Public Service Host as a Japanese CSNET and also the proposed linkage between U.S./Japan CSNETs with a two-way, high speed data communication circuit -- possibly by a direct satellite channel with roof-top antennas in the future.

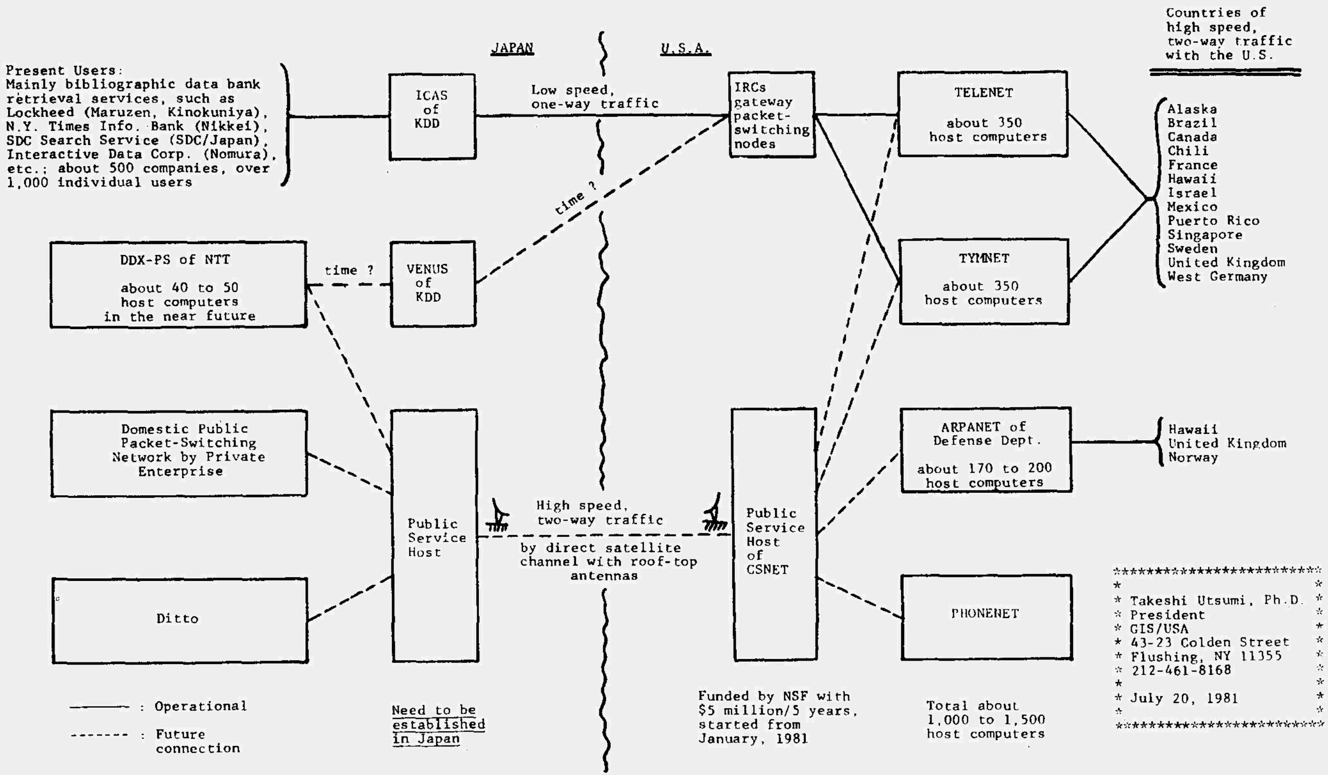
3. Protocols for Heterogeneous Networks (15, 45)

3.1 Introduction

Computer communication systems are playing an increasingly important role in military, government, and civilian environments. The host computers on a heterogeneous network are manufactured by different vendors and/or may be controlled by a variety of operating systems, command languages, and file systems. Currently, to effectively use such a network, a user must know their details on each host he wishes to access. As computer communication networks are developed and deployed, it is essential to provide means of interconnecting them

Figure 4

U.S./Japan Joint Research and Development System on Information, Computer and Communications
(Rainbow Bridge Across Pacific)



and to provide standard interprocess communication protocols which can support a broad range of applications.

The internetwork environment consists of hosts connected to networks which are in turn interconnected via gateways. It is assumed here that the networks may be either local networks, such as the Xerox's ETHERNET, or large networks, such as the DOD's ARPANET, but in any case are based on either packet-broadcasting Carrier Sense Multiple Access with Collision Detection (CSMA/CD) technology or point-to-point packet-switching technology, respectively. The active agents that produce and consume messages are processes. Various levels of protocols in the network, the gateways and the hosts support an interprocess communication system that provides two-way data flow on logical connections between process ports. Hosts are the sources and destination of messages. Processes are viewed as the active elements in host computers (in accordance with the fairly common definition of a process as a program in execution). Even terminals and files or other I/O devices are viewed as communicating with each other through the use of processes. Thus, all communication is viewed as interprocess communication.

The International Standards Organization (ISO) developed an architecture for defining standards for linking heterogeneous computers, the Open Systems Interconnection (OSI) reference model (the palindromic acronym ISO-OSI) which provides the basis for interconnecting "open" systems for distributed applications processing. The term "open" denotes the ability of an end-system of one manufacturer (or design) to connect with any other end-system conforming to the reference model and the associated standard protocols.

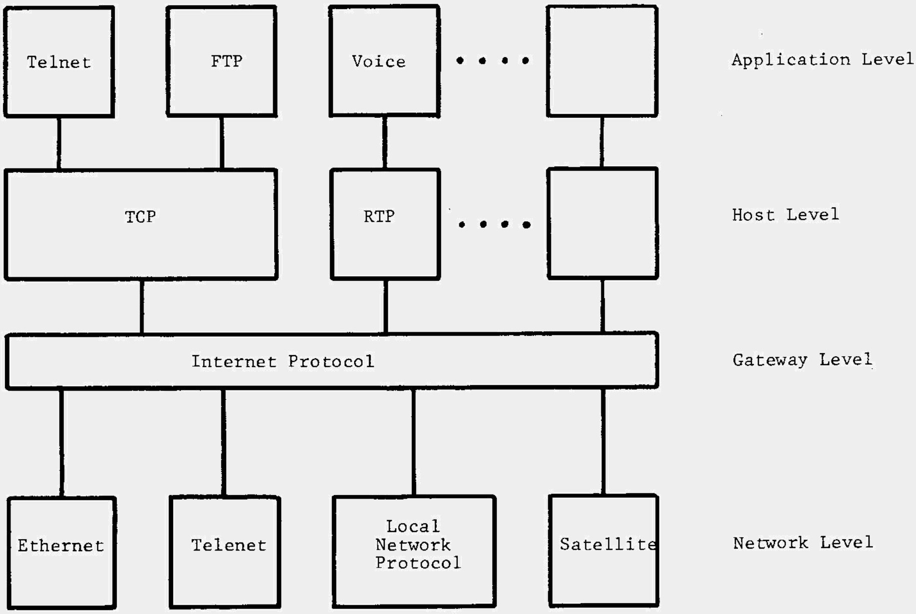
Because of the diversity of today's complex networks, these application processes can be correspondingly diverse. In the OSI model, these application processes, or APs, could be one or a group of activities that execute a specific set of procedures according to a computer's instructions. In distributed applications processing, it is frequently necessary for APs to communicate in order to perform a larger, more complex task than they could perform individually. Communications is likewise required for geographically dispersed computers that need to operate as a cooperative unit.

The International Telegraph and Telephone Consultative Committee (CCITT) recognized the significance of such a reference model to the design of new public data networks and related services. CCITT therefore appointed a special group to develop a compatible reference model for international data communications services. The OSI reference model will have a profound impact in the very near future on all facets of data communications and distributed applications processing.

In addition, the Institute of Electrical and Electronic Engineers has a draft standard at Levels 1 and 2, the U.S. Department of Defense has standardized higher level protocols, and the National Bureau of Standards (NBS) is also working at the higher levels with the so-called "Datacom" model (4). As will be described later, the layer architecture of ARPANET is centered around Internet Protocol (IP) as branching other layers upward as well as downward (Figure 5, (44)). Also, ARPANET's approach is based on the datagram in contrast to CCITT's and NBS's on virtual circuit network. Expensive error detection and correction mechanisms are left in upper layers for the former whereas they are in lower layers for the latters.

Figure 5

Protocol Relationships



3.2. Layering by Function(15, 48)

There is a continuum of functions involved in an OSI communication. Consequently, ISO chose the principle of layering through partitioning, or logically grouping the necessary functions, as the method of defining the reference model. The firm basis of a seven-layer structure for OSI is now accepted (Table 1, (15)). Each layer is composed of functionally separate units that provide specialized services. However, the seven-layer architecture of the ISO-OSI model is just a set of guidelines, not a well-defined standard yet. This is particularly true of local networks, which might even separate the lowest levels and lump all the higher levels together. Eventually, as the use of networks expands, particularly at the local level, the need to standardize at all seven levels will arise.

On each level of the ISO-OSI reference model, a given node in a network communicates with another node; all communication is supposed to remain at a particular level at all times. Rules and conventions used at this level constitute the protocol of the level. Since all levels are involved in every message, however, the communication at a particular level is virtual. Levels are joined within a node by interfaces, each of which defines how the lower level serves the upper level.

Table 1

Seven-Layer Structure
for
Open Systems Interconnection (OSI)

Level	Notation	Function
	End-User Application Process	
7	Application	: directly serves the communicating end-user application process by providing the distributed information service appropriate to the application and its management.
6	Presentation	: provides for any necessary translation, format conversion, or code conversion to put the information into a recognizable form.
5	Session	: coordinates the interaction between the communicating end-application processes.
4	Transport	: assures end-to-end data integrity and provides for the required quality of service for exchanged information.
3	Network	: governs the switching and routing of the information to establish a connection for the transparent delivery of the data.
2	Data Link	: handles the transfer of a unit of information between the ends of the physical link.
1	Physical	: provides for the transparent transmission of the bit streams to the connecting physical transmission media.

The application layer at Level 7 of ISO-OSI model directly serves the AP and provides the window through which the communications move in and out of the OSI Environment (OSIE). The layer provides distributed services to the AP for its management and performs the functions that initiate the overall interconnection and data transfer. Also, user-specified parameters are made known to the OSIE through this layer.

At this level network transparency is maintained, hiding the physical distribution of resources from the human user, partitioning a problem among several machines in distributed-processing applications, and providing access to distributed data bases that seem, to the user, to be concentrated in his CRT terminal.

Peer protocols for the application layer provide the necessary procedures for the functional units within a specific layer to interact with each other and exchange information. Particularly the user-application protocols enable remote job entry, subprocess selection (specific module within an application), and file access. Additional user-application protocols may be industry-specific, such as for banking or airlines operations, and continuous system simulation for our GLOSAS Project.

3.3 Some Developments on Higher Level Protocols

Figure 5 (45) shows the protocol layering and hierarchical relationships of various protocols of ARPANET at higher levels than X.25. They are defined as follows, starting at the lower level and working up:

3.3.1 Internet Protocol (44)

The Internet Protocol (IP) is designed for use in interconnected systems of packet-switched networks (Figure 6, (44)). The IP provides for transmitting blocks of data called datagrams from sources to destinations, where sources and destinations are hosts identified by fixed length addresses. The IP also provides for fragmentation and reassembly of long datagrams, if necessary, for transmission through "small packet" networks. IP falls in between Levels 3 and 4 of ISO-OSI model.

3.3.2 Transmission Control Protocol (45)

The Transmission Control Protocol (TCP) is a functionally rich protocol that provides a highly reliable host-to-host protocol in packet-switched networks which falls in between Levels 4 and 5, and especially in interconnected systems of such networks, thereby providing a reliable process-to-process communication service in a multi-network environment. In principle, the TCP should be able to operate above a wide spectrum of communication systems ranging from hand-wired connections to packet-switched or circuit-switched networks.

The TCP fits into a layered protocol architecture just above a basic IP which provides a way for the TCP to send and receive variable-length segments of information enclosed in internet datagram "envelopes". The internet datagram provides a means for addressing source and destination TCPs in different networks.

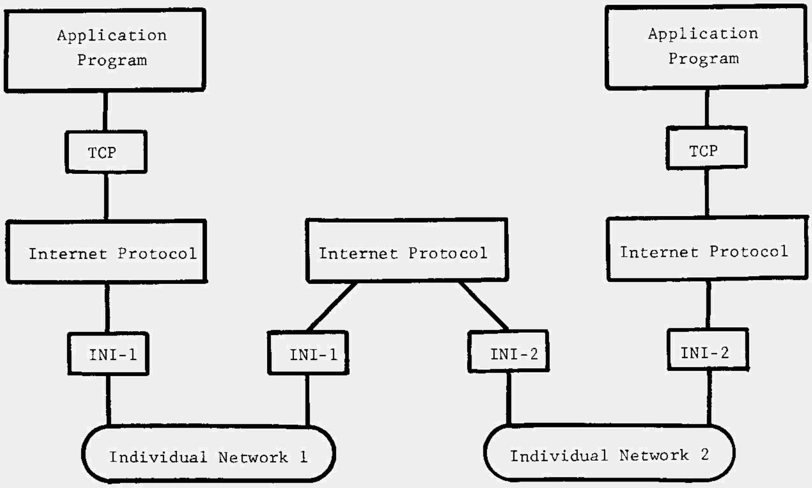
The IP also deals with any fragmentation or reassembly of the TCP segments required to achieve transport and delivery through multiple networks and interconnecting gateways.

3.3.3 File Transfer Protocol (47)

The objectives of File Transfer Protocol (FTP) are (1) to promote sharing of files (computer programs and/or data), (2) to encourage indirect or implicit (via programs) use of remote computers, (3) to shield a user from variations in file storage systems among Hosts, and (4) to transfer data reliably and efficiently. FTP, though usable directly by a user at a terminal, is designed mainly for use by programs. The FTP commands specify the parameters for the data connection (data port, transfer mode, representation type, and structure) and the nature of file system operation (store, retrieve, append, delete, etc.). FTP includes Levels 6 and 7 of ISO-OSI model.

Figure 6

Internetwork Application Processing



TCP: Transmission Control Protocol

INI: Individual Network Interface, such as Levels 1 to 3 or X.25 of ISO-OSI reference model

Individual Network: such as ARPANET, TELENET, Ethernet, or satellite network

Files are transferred only via the data connection. Often it is necessary to perform certain transformation on the data because data storage representations in the two systems are different. It may be desirable to convert characters into the standard NVT-ASCII representation when transmitting text between dissimilar systems. The sending and receiving sites would have to perform the necessary transformations between the standard representation and their internal representations.

A character file may be transferred to a host for one of three purposes: for printing, for storage and later retrieval, or for processing. If a file is sent for printing, the receiving host must know how the vertical format control is represented. In the second case, it must be possible to store a file at a host and then retrieve it later in exactly the same form. Finally, it ought to be possible to move a file from one host to another and process the file at the second host without undue trouble.

3.3.4 Virtual Network File System (38)

A Common Command Language (CCL) and a Common Command Language Protocol (CCLP) allow system independent manipulation of files and file management systems in a complex, heterogeneous computer network. The CCL and CCLP address the problems created by diverse command languages, formats, and file accessing capabilities of dissimilar computers that impede effective use of network resources.

Creating a standard command language, such as CCL, with its command language protocol will permit the exchange of commands between dissimilar computer systems. A CCL is a set of commands for some sets of user level functions that remain invariant throughout the computer network. The important feature of a CCL is that the language and the operation (i.e., syntax and semantics) are the same for each computer system in the network. A CCL provides the user with the interface (commands) and the actions (functions) for each defined command. In order to provide these services across a network, a CCLP defines the method to exchange the needed information. The CCLP exists only to support the CCL. The CCLP will not be accessible or visible to the user except for receiving status type message that the CCLP generates. CCL commands operate on a virtual network file system that is a standard image of a file system permitting the exchange of file information between different computer systems.

3.3.5 TELNET Protocol (46)

A TELNET connection is a TCP connection used to transmit data with interspersed TELNET control information. The purpose of the TELNET Protocol is to provide a fairly general, bi-directional, eight-bit byte oriented communications facility. Its primary goal is to allow a standard method of interfacing terminal devices and terminal-oriented processes to each other. It is envisioned that the protocol may also be used for terminal-terminal communication ("linking") and process-process communication (distributed computation). TELNET includes the functions of Levels 6 and 7 of ISO-OSI model.

A network Virtual Terminal (NVT) eliminates the need for "server" and "user" hosts to keep information about the characteristics of each other's terminals and terminal handling conventions.

3.4 Summary

The ISO's work is advancing rapidly to produce a basic reference model, such as on the session level. A major task ahead is the development of protocols for the layers, particularly at the upper layers where there presently are no established standards. The ISO's goal is that the reference model accommodate as many application processes as possible. As the technology evolves, however, protocols at different layers will be able to be revised or replaced without affecting the other layers. Then, as new applications arise, they can likewise be designed to conform to the reference model. Figure 7 indicates a possible multi-host-to-host computer conversations with internetwork connections.

4. Computer-Based Electronic Message Exchange Systems

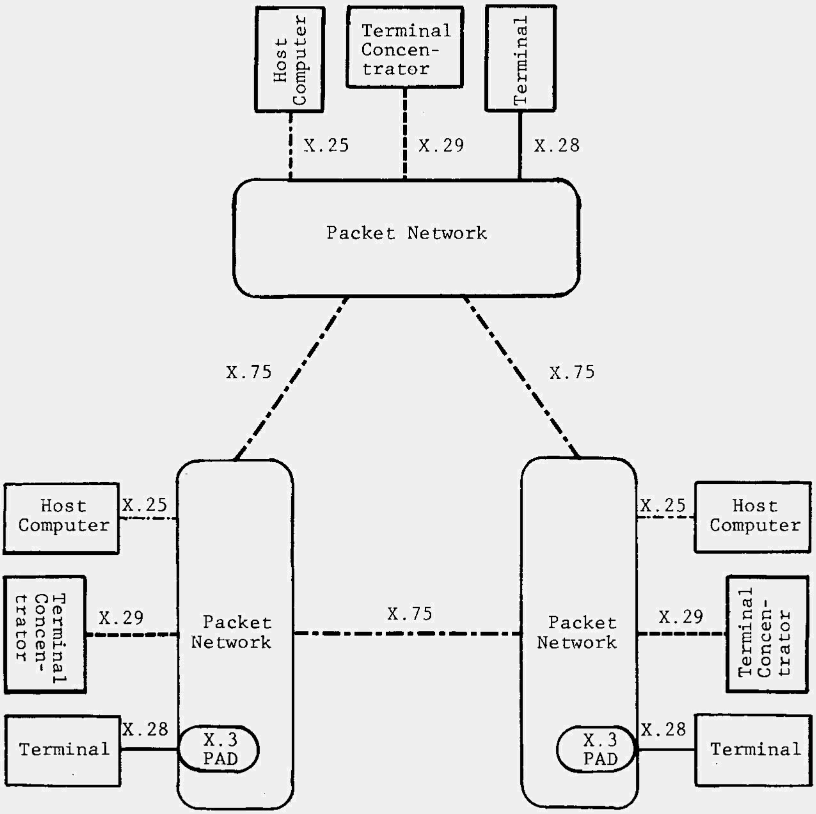
4.1 Introduction

The computer is now beginning to be used similar to communications among human beings. This communications form on a computer network, i.e., the electronic message exchange for human to human document transfer via electronic transmission, differs so much from other available communication forms, such as face-to-face conversations, letters, and telephone, that it may be termed a new communication medium (37, 41, 42, 55 to 58).

Both electronic mail and computer conferencing represent the use of computer systems, telecommunications networks and terminal equipment as a means of inter-personal communications. The boundary between them is not, however, always distinct, because the technical features of the two are very similar; the real distinctions lie in the way they perform basic communication functions and the way the user may take advantage of the systems to perform communication tasks (37).

Figure 7

Packet Switching Standards



4.2 Electronic Mail

Electronic mail might be defined as:

> The use of shared computer systems via computer networks to exchange messages as individual text files. Management of the received messages is performed by the individual recipient and is not content-sensitive unless the user explicitly organizes messages on this basis (37).

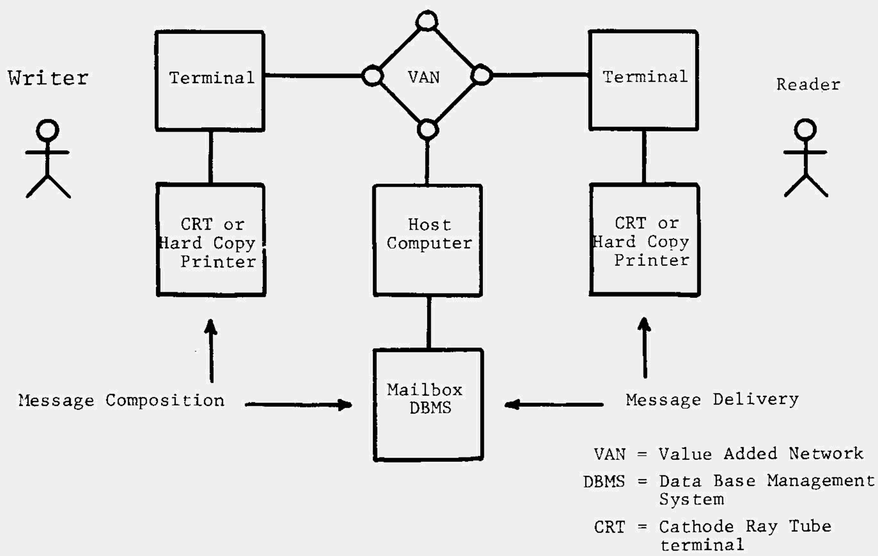
Each user is provided with an electronic "mail-box" which he can access from his office, his home or from out-of-town locations using the telephone and a desk top or portable data terminal. A number of ASCII-compatible communicating word processors may also be used. Messages can be delivered to a user's electronic mailbox to be called for at his convenience. Alternatively, messages can be delivered in printed form directly to a specific data terminal, telex or TWX machine or by Mailgram in the U.S. (19).

Each user secures the privacy of his own "mailbox" by selecting a personal password, known only to himself. He may change his password instantly, if he wishes. The other advanced features incorporated into some electronic mail services are: validation procedures for report and form input; electronic indexing and storage of messages; an electronic directory of subscribers nationwide; and the ability to send multiple-address or broadcast messages to any number of people.

Figure 8 (36) shows a general schematic of a computer-based message system (CBMS). There are three constituent technologies: (1) word processing to assist the user in message composition, (2) computer networking to assist in message delivery, (3) data base management to provide for storage and retrieval of information in electronic mailboxes. Thus, CBMS offers the full power and flexibility needed for successful integration of electronic mail with word processing, data processing, and office automation activities.

Figure 8

A Computer Based Message System (CBMS)



A good electronic mail system offers more than just electronic messages and correspondence management. It provides for general purpose information management. The features needed in an electronic mail system to provide the more general capabilities include three basic building blocks: documents, files, and forms.

In the future we can look for CBMS offerings which take the familiar concept of a form and go several steps further. For example, future CBMS packages will offer a "smart" form with intelligence for handling the information contained in the form. A form might be specified, for example, for checking the contents of a given field of a message for accuracy or completeness. A smart form can take further steps based on the contents of that field. For example, it might fill out other fields in a specified way, or ask the user questions, or perform calculations based on the contents of one of the message fields. In time, smart forms will grow to provide a full data entry and printing language for CBMS users. They will make possible the automation of complex, structured office procedures such as the budgeting and forecasting process (25, 36).

4.3 Computer Conferencing System

4.3.1 Conventional Face-to-Face or Telephone Conference (26)

In a conventional conference the participants follow certain rules in an effort to provide each a chance to air his views and all a chance to hear them. Formal conferences rigidly adhere to highly institutionalized parliamentary procedure, but even small informal groups usually accept tacitly - perhaps even unconsciously - much simplified but still analogous sets of rules. These codes of communication behavior impose a synchronous regimen on the proceedings; only one person speaks at a time, and all participants who wish to address a given topic do so in turn. In general, participants must be present in order to take part in the proceedings effectively. Conferences are of course held over the telephone to overcome geographic separation, but all participants must still take part during the same time interval, and special procedures such as roll calling or unceasing speaker self-identification must usually be invoked to avoid chaos.

4.3.2 Computer Conference

Computer conferencing might be defined as:

> The use of shared computer files, remote terminal equipment, and telecommunications networks to facilitate interactive group communication where face-to-face contact is either not possible or less desirable. In the course of computer conferences, messages are automatically saved according to the different tasks or topic areas, represented by distinct "conferences" (37).

Computer conferencing allows a group of people who wish to communicate about some issue to do so at low cost even while avoiding the time and expense of travel. By typing at, and reading from, their computer terminals, and by having the computer store and deliver messages, the people give and receive information in much the same fashion as at conventional meetings. Unlike face-to-face sessions, however, the conferees are freed from space and time constraints: Individuals can set up their own schedule of sessions at the terminal. The computer will bring them up to date in the discussion when they next sign on. Also unlike face-to-face meetings, everyone on-line can speak (type) at once while the subject is still fresh in his or her mind (34). The role of the computer is here to store and identify all inputs, forward them to each other participant whenever he or his agent is "on-line", record and tally votes, and provide various editing and sorting services to facilitate the organization of lucid information.

Unlike most forms of telemediated, interpersonal communication, computer conference systems allow individuals to interact in "real time" (synchronously) as well as asynchronously (delayed messages) without an appreciable difference in the commands used or even in the presentation format of information. Synchronous interaction in a computer conference is obviously not quite as responsive as face-to-face or non-computer-based conference interaction. To prevent garbled messages there is some delay in the presentation of messages when in a synchronous mode of interaction. Electronic mail is restricted to the asynchronous mode of interaction.

4.4 Benefits

Some of the recognized benefits of CBMSs may be listed as follows:

(1) Permanent, searchable, stored record (of all communications desired),
(2) Simultaneous activity of the communicating individuals is not required,
(3) Meeting schedules are unnecessary,
(4) Geographical proximity or distance is unimportant to successful communication,
(5) The communication is both sender- and receiver-controlled; there are no interruptions,
(6) Fast delivery of accurate information at low costs,
(7) Automatic distribution of information (to designated persons).

The better CBMSs are designed for easy use by anyone. A great deal of effort has gone into the "human engineering" of these systems, leading to short learning time and easily managed interaction with the program using almost-natural English. Since the majority of messages are received when users are not on-line simultaneously, the speed at which a user completes to type a message is unimportant. The value of CBMS has to do also with the management of information and communication. The systems should then be thought of as new tools which complement, rather than replace other forms of interpersonal communication.

4.5 Summary

Computer conferencing is a new communications technology which will affect the efficiency and quality of decision-making processes within existing groups and institutions. Its use as one of the primary communications modes among geographically dispersed groups of people will probably be made inevitable because of cost and convenience factors. The use of current technology, such as the micro-computer and global public VANs, enables a user to communicate messages and other written materials to persons all over the world. Collaborative activities of international decision-makers in the formulation and analysis of public-policy can be enhanced and ensured by the delivery of more frequent communications and an environment for shared development (and evaluation) with advanced computer communications systems over the global VANs. Rapid and worldwide dissemination of related information will accelerate collaboration among experts in various countries in policy analysis and evaluations, and meet today's need to solve closely interdependent problems (26).

The computer conferencing system also accelerates the project progress, and reduces at the same time the necessary number of meetings, thereby diverting the savings to other important facets of the project, like communication and computer costs. By removing most of the barriers to communication created by space and time, it may also facilitate the emergence of new life styles and organizational forms (22). Within the next decade, it will begin to be used more and more as a communication medium which takes the place of many expensive and time consuming face-to-face meetings in business, government, and among the "invisible colleges or research institutions" of scientific specialists in academy and research fields of global scale. The computer conferencing system accordingly offers many opportunities for the innovative application of a new technology in the interests of democratizing and humanizing society.

5. Modeling with the Aid of Communication Tools

5.1 Introduction

Models are used in the decision-making process to study sensitivity and side effects of various decision parameters prior to their implementation. More precisely, modeling should refer to the gathering and structuring of data in such a way that the values of the parameters, the initial values of the variables, and their interrelationships are formalized. The term simulation, strictly speaking, should be reserved to the use of a model to carry out "experiments" specifically designed to study selected aspects of the simulant, i.e., the real-world or hypothesized system that has been modeled. Gaming, refers to man-machine-simulation in which human judgement is exercised to influence the dynamics of the model during the course of a study (35).

All simulations can also be described in terms of the following three modes:

(1) man-simulation in which human beings model a simulant of the real world or hypothesized system and the decision-makings are entirely made by them with computer conferencing system.

(2) machine-simulation in which the structure and activity as well as decision-making functions are entirely embedded in computer software;

(3) man-machine-simulation in which computer software is used to model part of simulant and the decision-making apparatus is divided in some manner between a human being and computer.

Gaming simulation, which will be discussed later, implies to man-machine-simulation.

Analytical information with the use of computer simulation can provide accurate assessments of cause-and-effects of various decisions prior to their application on various socio-energy-economic problems. Such information is particularly valuable in analyzing the interrelatedness between the global issues at hand. Namely, the function of computer simulation is not to produce prescriptions or courses of action for complicated problems. Rather their purpose is to assist the decision-maker in assessing the interdependencies of the problem's variables.

In essence, a planning process with computer simulation can thrive on the economic and political interdependencies among nations. The new planning discipline favors the notion that solutions to world problems lie in joint application of the technologies and intellectual resources among nations. Such a planning activity (amongst international decision-makers) requires the development of various descriptive and/or analytical models and data management activities, which can substantially assist the crisis managers in understanding the ramifications of another's statements and proposals.

Since the computer simulations are used by analysts to assess the interdependency of the various sectors of our world, the models should be put together by individuals who are experts on each sector. This requires the coordinated efforts and structured interaction among international and interdisciplinary experts, who put together submodels of each sector involved for the computer simulation. Accordingly, the current mode of running a simulation on a single computer should be replaced with a globally distributed computer simulation enabling the participants to interface and execute simultaneously the models of the various sectors or countries to be considered.

5.2 Modeling Process

5.2.1 Model (17, 18, 27 to 32)

The functions of policy planning and forecasting cannot be separated. The planner cannot plan for the future unless he has some notion, either implicit or explicit, as to the future state of the social sector of interest. Alternatively, the forecaster cannot make a projection for the sector without making assumptions about the plans for that sector and about the estimated effectiveness of those plans. Though no procedures or rules of conduct can be prescribed explicitly, it is assumed that the activities of planning and of forecasting should be mutually supporting and must, therefore, proceed in a joint fashion.

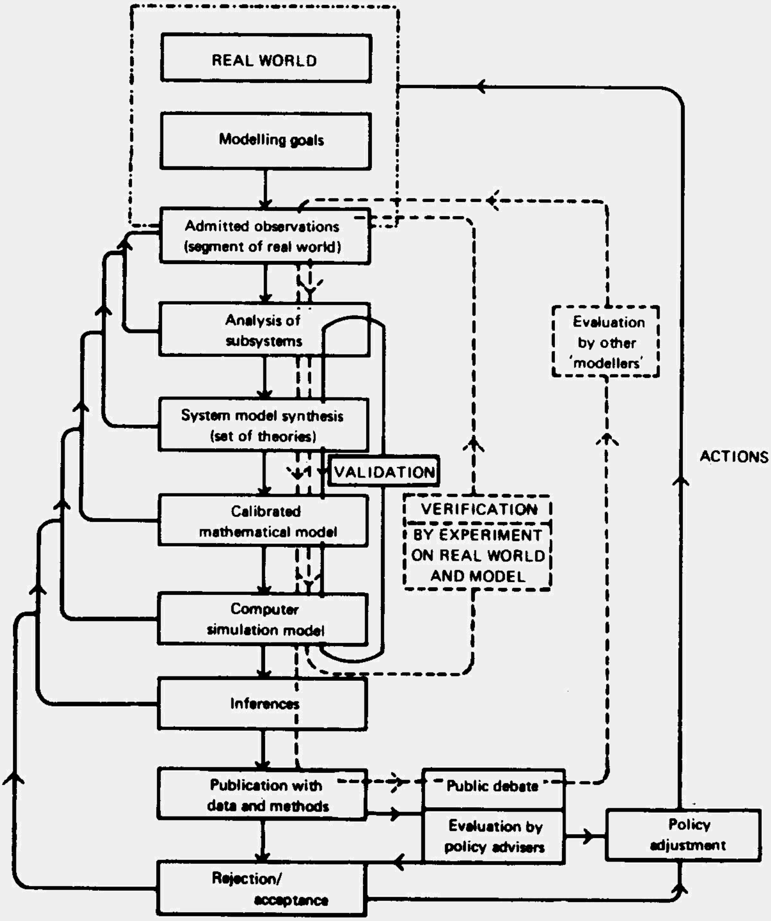
With the introduction of computers, the ability to model very complex systems or processes increased dramatically. In particular, it appeared that complex social systems might be better understood using computer-based mathematical models. Accordingly, policymakers in city, state, and federal governments as well as in private corporations have often made considerable investments of staff and money in the development of large-scale computer models as decision-making aids.

5.2.2 Modeling Difficulties

Because of the difficulty of gaining a level of consensus in complex policy issues, where virtually all currently used theories are inadequate and precise data unavailable, models are rarely likely to be accepted as "objective" and adopted totally by all parties to a decision. Any model is therefore best viewed as a component part of the advocacy process, since one of the roles of a model is to help people subscribing to a particular view to evaluate it more rigorously. These factors of modeling process, as seeing them from total perspective viewpoints (Figure 9, (7)), may contribute appreciably to many of the deficiencies in the

Figure 9

The Model Building Process and Its Interaction with "The Real World"



past modeling projects. It is then clear from this range that the modeling activities -- particularly those at the beginning and end of the process -- are heavily dependent on the capability for effective communication. Indeed, many of the evaluations of the past modeling process point to communication as a major deficiency (27), especially in their effective application to policy decisions.

5.3 Communication Needs in the Modeling Process and Computer Capabilities

The use of large-scale models as decision-making aids introduces an immediate and explicit communication problem. Different people are involved in the various stages of model development and usage. This segmentation means that some formal communication must be established, especially between the builder and user. Lipinski's survey (27) of modeling process deficiencies point to four major problem areas:

(1) communication between model builders and users,
(2) communication among model builders,
(3) documentation,
(4) validation.

The crux of the problem is that builders and users of models work in two different worlds, and each has its own world view. The world of the builder is theoretical; that of the user/policymaker is pragmatic, with political pressures to which the user must respond. The survey mentions that the transfer of the model must be an iterative process involving the gradual acceptance of:

(1) philosophy and methodology of the effort,
(2) technology and computer programs,
(3) results of the model.

To accomplish this, one must participate in the communication process to break through the extensive organizational and perceptual barriers, and take advantage of advanced computer capabilities to solve the technical problems.

5.4 Summary

One of the most difficult problems in the administration of a large, complex model study is the organization and coordination of the working team (12). Almost inevitably, one is led to a considerable degree of specialization, sometimes along the line of professional skills or else, more commonly, along the lines of problem technologies. In the course of a study, these specialists must interact in fantastically complicated ways. The interactions among study team members require a little more than good team spirit to assure that the parts fit together and that the formulation as a whole is valid.

A computer conferencing system can potentially play three key roles in the area of improving the utility of modeling and simulations. The first is in the formative process where a wider range of expertise can be brought to bear and the opportunity to provide better interfaces between modelers and decision-makers presents itself. The requirement here is for data processing tools to make specification of model assumptions and structures easier to analyze, for feedback purposes, inconsistencies and differences of judgements among the discussants. The second area is in the actual execution of a simulation. The objective here would be to emulate the real world communication and decision processes associated with the system being modeled. The third area is the interpretation and validation of the results of models, where a group of people comprising a variety of backgrounds is usually required (59).

Current vogue in world modeling portends to become a major beneficiary in the modeling field of a viable computer conferencing network consisting of geographically dispersed international model builders, database specialists, technical experts, government policy makers, and informed citizen, etc.. Thus, communication links among them is a mandatory necessity for world modeling (26). Efforts to build models for testing of "global" decisions, as in the "Club of Rome" (7), can only be successful if international model-makers have access to an appropriate data base through space communications. These efforts must succeed if man is to survive -- they will succeed if we have the ability to communicate (20).

6. Distributed Computer Simulation System

6.1 Introduction

The advent of distributed computer networks was accomplished amongst others by the creation of the "virtual terminal" concept which enables almost absolutely error-free handshaking procedure for data transmission between network entities. These networks made it possible to share resources of particular software, data bank, computing power, etc., among remote terminals. This sharing resources has become to be widely used with another advent, the value added network (VAN) concept and the establishment of a public packet-switching network. Namely, by sharing high costs of data transmission lines, a number of remote terminal users can now have access with particular resources of their choosing.

Trends so far experienced with private VAN, such as ARPANET, or with public VAN, such as TELENET or TYMNET, have however been to provide aforementioned computer oriented information resources individually to remote users. Next comes the beginning of globally distributed information processing, where there is not only data communication among computers but also collective and integrative use of programs, models, databases in dispersed, dissimilar computers of the global VANs. Particularly a distributed computer simulation system (DCSS) enables such use of models, which are written by various continuous system simulation languages and reside in various dissimilar computers around the network. It is therefore suggested here that a comprehensive study with integrated models should be made with the use of distributed computer network as dispersing various sub-models to dissimilar computers around the network.

The distributed information processing approach of GLOSAS will be the foundation of a global decision support system (GDSS) (within the public domain). Firstly, it is envisioned that the non-data processing individuals who make daily requests for data needed to conduct business and to drive other processes, will require an information system containing a flexible data-base with a hierarchical structure. The database, possibly located in dispersed locations, should not be self-contained in as much as the user should be able to query it to obtain data in various formats. Secondly, the current mode of running a simulation on a single computer should be replaced with a globally distributed computer simulation enabling the participants to interface and execute simultaneously and interactively the sub-models of the various sectors or countries to be considered. The major technical problem is providing for the collective and integrative use of appropriate models.

6.2 Large-Scale Socio-Energy-Economic Simulation Modeling

Various energy models have been constructed utilizing highly developed rationalizations of particular viewpoints and methodologies. These individual models have also been constructed with a single computer and a single language. Due to growing demand for higher credibility of simulation results, however, models tend to become complex and large-scale, often occupying the full capacity of the largest computer core memories presently available. After much of such effort, model builders realize that the resultant simulation studies comprehend only parts of the whole picture of complex problems; and the model users must demand from the builders more comprehensive descriptions.

The model builders forced to the limit of their capabilities must ask participation of other workers who have, or can devise, complementary models. At this time, however, it becomes evident that each model has grown so large in size that it cannot be integrated with the others into one overall model which can be handled by one computer. The model builders will also often find at this time that their models have not been built into such a modular format, that the integration with one or more others is next to impossible. Subsequently, the individual models must be reduced in size so that any possible combination can be executed with one computer. During this process, however, the credibility of each large scale model will be lost, negating previous efforts and attempts to increase the credibility with large, comprehensive and detailed models.

Accordingly, high credibility of global socio-energy-economic simulation models can only be achieved when each component system (or country) is simulated by the expert of the system (or country). In order to achieve the high credibility, the following problems have to be considered;

(1) Each component model has been constructed by the expert with his preferred computer, which is often dissimilar to other experts' computers, and with his preferred language, which is also different from other experts' languages;

(2) Each component model is highly interrelated with others, especially for the macro-economic models of various countries;

(3) The experts of various countries cannot congregate at one place for a long period.

The newly established global public VAN can be effectively utilized as the remedy to these problems, by constructing the globally distributed socio-energy-economic simulation system on the VAN. The system will enable to execute simultaneously the models of various countries which will be connected by experts of those individual countries. This should certainly increase the credibility of the coordinated studies.

6.3 Distributed Energy Database Management System

In recent years integrated databases have become increasingly more prevalent in the operations of buisness and industry. In the interest of efficiency, security, and integrity most of these database systems are self-contained to the extent that the application programs used for interacting with the database are part of the system, and as such, the only way a user can interact with the system is by passing parameters to these fixed application programs. This procedure suffices for the predictable, repetitive portion of a business operation which can be analyzed, understood, and captured in the form of appropriate application programs. Moreover, it is a straight-forward matter to justify the database system financially by comparing the development and operating costs of the system with the costs of the present operation. Unfortunately, there are major application areas which cannot be justified financially in a straight-forward manner and which have a requirement for an integrated database that cannot be satisfied by the self-contained database system.

Many applications are characterized by the necessity for highly skilled, non-data processing professionals to use the computer as a tool for performing their work. The interesting point about the requirements for these applications is that there can, 'and should not, be any way of limiting the types of interactions, analyses, or models the user desires. It is clear that a self-contained database system would not suffice in this case, since there is no reasonable way to contain all of the possible applications a user might want.

The primary requirement for public policy-making in the area of energy resources and their utilization is a flexible information system which can handle all of the information needs of administration staffs as well as of the researchers who must build the related models. The system must be flexible since unforseen uses and needs for the data inevitably arise in so volatile an area as energy; and constraints imposed by changes in the quality, availability, and protection requirements of data are constantly in a state of flux. The operational requirements run from simple query and update to the building and use of complex models (11).

6.4 Summary

Even if the integration of complementary models succeeds, there will next be another tremendous effort necessary to integrate the models of each country. This is the so-called "bottom-to-up" approach which is now often denounced (5). Actually, the chance of success with this approach is very small and a large amount of effort may be wasted at every attempt to integration.

In contrast to the above, the GLOSAS Project attempts with the so-called "top-to-down" approach, i.e., from the crude modeling of an international energy system to refine and model in detail domestic micro-industries. The complementary component models of those micro-industries will be distributed to dissimilar computers preferred by the experts of the participating industries. The DCSS will then allow a significant cost saving without becoming entangled in expensive reconstruction of substitutable and/or complementary component models from scratch.

> Until recently, the design of an international data communications network depended primarily on technology and on-line and equipment costs. Now, a new factor has entered into design considerations, and that is the potential restrictions on transborder data flow which may be imposed by many European and other countries (33). Many nations are expected to have national data-protection laws (1, 43), which would require that all data files remain within the country of origin, and restrictions would be placed over the kinds and amounts of information that can be transmitted across national borders. If implemented, such rules could force to set up local operations to handle the data that is collected within those countries, implying the vital necessity of developing globally distributed computer processing capabilities (68).

This GLOSAS Project then proposes the use of a distributed computer network for splitting various component models in different computers around the global VAN. This is an application of the distributed processing technique which is an increasingly important trend for computer users today.

7. Distributed, Interactive Gaming Simulation

7.1 Introduction

The rationale for the recent attractiveness of gaming simulation becomes evident when we examine the simulants which the gaming simulation seeks to mimic. Within the sphere of the energy-resource-environment (ERE) sector, there are problems involving interactions between various subsystems that go beyond normal human ken and which do not yield to conventional problem solving and communications (14). The nature of society's challenge is not only to determine solutions for these problems, but more crucially, to develop a method of communication which allows the problems to be adequately described and comprehended. To this end, gaming simulation is a communication and problem-solving vehicle allowing for participants to comprehend the "whole" problem before any component of the "whole" may be investigated. (In this way, it is a gestalt process.)

Gaming simulation is a sophisticated, "integrated", communication mode, which if coupled with a computer conferencing system and DCSS takes on features which cannot be matched by any other communication and simulation mode available today. As a communications mode:

(1) Gaming simulation normally employs several languages, including a game-specific one;

(2) The interaction pattern among game players is not single one-way or two-way communication, nor sequential dialogue between a central speaker and an audience, but rather a very productive multilogue interaction which is necessary to the simulation's ability to convey gestalt;

(3) It employs combinations of interactive communication and man-machine-simulation technologies.

There are two essential features that distinguish interactive gaming simulation from ordinary simulation modeling:

(1) Interactive simulation includes the relevant decision-makers among the elements being simulated by knowledgeable individuals acting as players;

(2) It is dynamic in nature, in that it utilizes the expertise of these players to improve the structure and numerical parameters of the game between plays.

The purpose of gaming simulation is not so much to solve problems directly but to help the analyst in the development of models that gradually become more and more appropriate for dealing with the real-world problem situation (21).

7.2 Interactive Evolvement

Once gaming simulation models are developed, they should not remain static entities, but open for continued discussion, evaluation, and change. Figures 10 and 11 (14) display this iterative process. During the critique, players must be encouraged to focus on the reality which the gaming model attempts to represent. If there are challenges by the players, these must be resolved by offering evidence to sustain the model, or through the modification of the model to more accurately reflect the new understanding of reality. Players themselves become part of the gaming multilogue gradually. This is necessary because each participant must develop his own heuristic procedure which will structure (to his satisfaction) his conceptualization of the complex reality. Discussion of the object system is prompted by the deliberate introduction of circumstances which tend to sharpen the player's perception of dynamic relationships. Once part of the discussions, the player's involvement enhances the "pulse" of the game which flows for the duration of the exercise. The gaming simulation designer can utilize each player's concept report - a written formalization of the individuals mapping of the complex reality. So, the interactions between game players and between players and designers contribute to a better intuitive understanding of the problem structure. An essential part of the routine of playing the game simulation is a constructive debriefing or review session in which the participants are asked to (21);

(a) a self-critique, --- what would I do differently if I were to play the gaming simulation again?

(b) a critique of the gaming simulation, -- what numerical inputs, or what structural components, of the gaming simulation should be altered in order to achieve greater realism?

7.3 Gaming Simulation Requires a Synthesizing of Methodologies

The gaming simulation, although simple enough in structure to be played by a variety of players, must be rich enough in methodologies to describe clearly the substance of complex processes. The participants must not be constrained by the

Figure 10

Future's Meta Language
Communicating Through Gaming Simulation

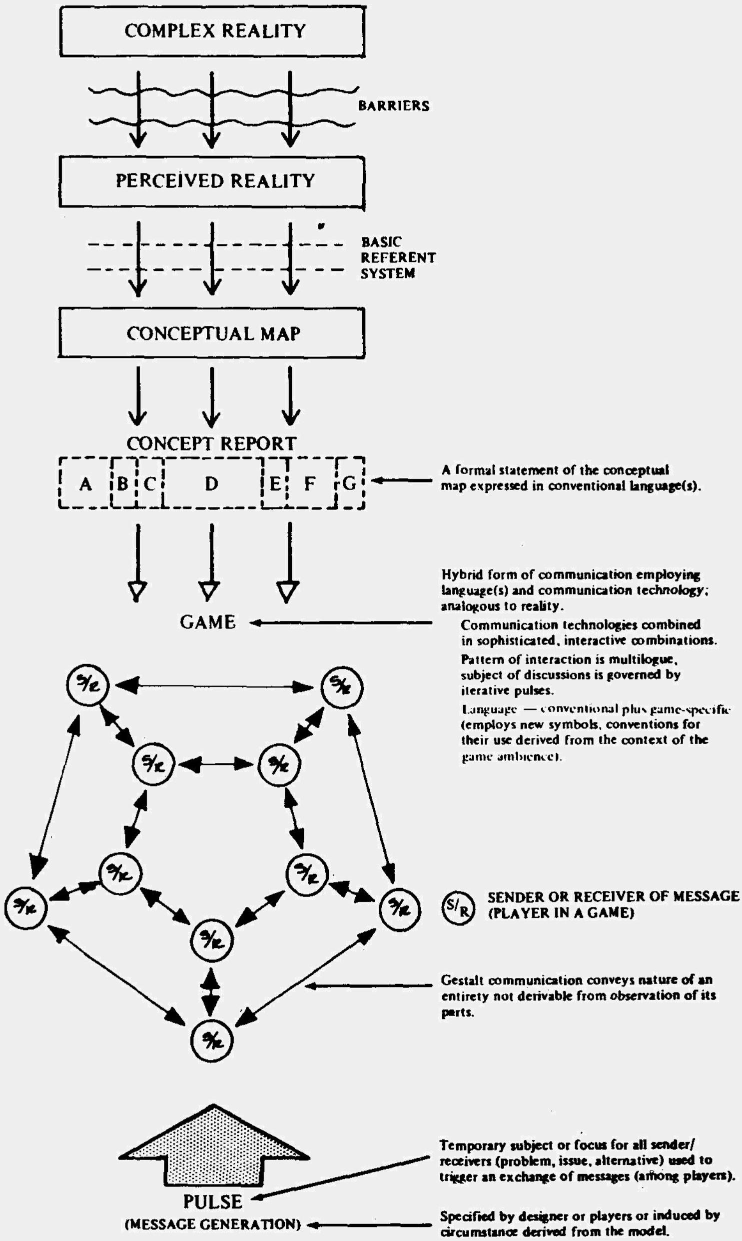
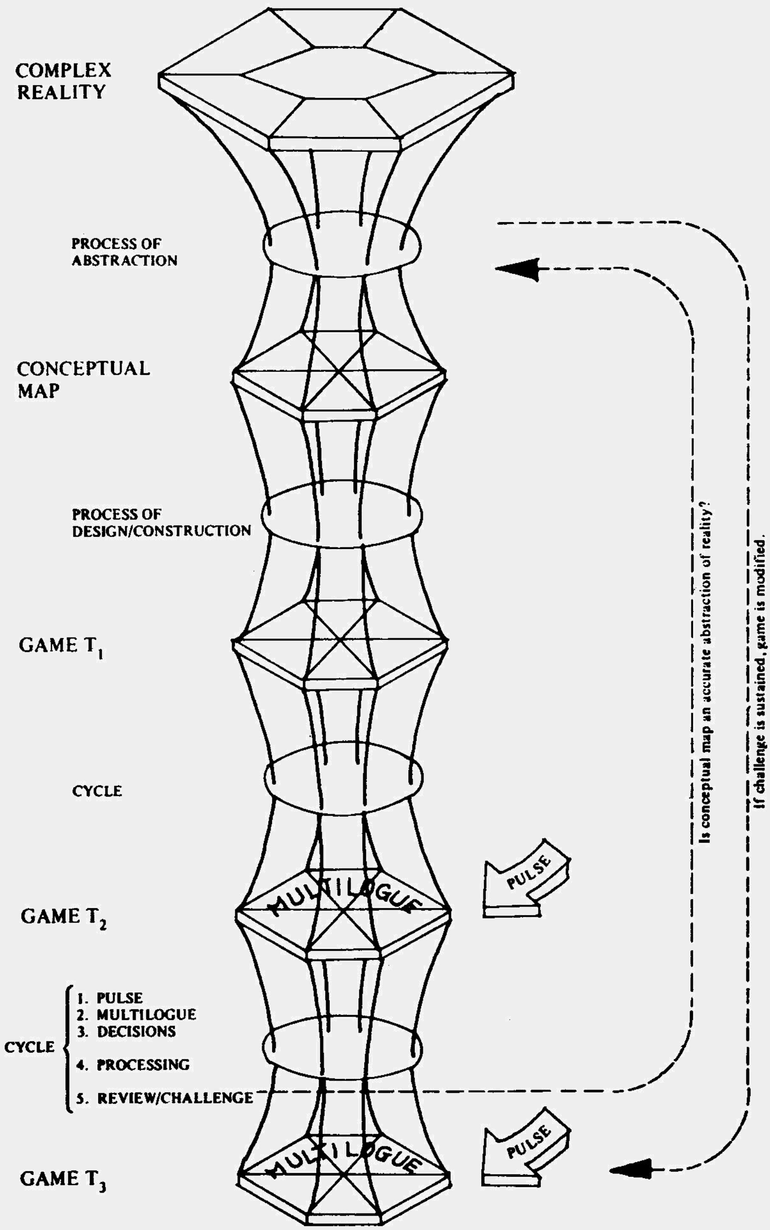


Figure 11

Challenging the Game Model



inability of the simulation to present the analysis in ways which the participants deem appropriate. Algorithms must be embedded for use by the simulation which operate on diverse categories of problem-solving. The structure of the models must consider variables which describe stochastic activities. Wherever possible, the model must operate over constraints imposed by the model (or by the decision-maker) in order to estimate the effects of various decisions.

Methodologies to be used for this purpose can be classified as either dynamic or static. The socio-economic systems to be simulated exhibit complex interractions between variables. Since social systems are constantly in states of flux, they must be treated dynamically. Furthermore, the simulation takes on enhanced realism only if it considers the complex involvement between policy-makers. The primary technique here must also be adept at "guessing" at the structure of socio-economic systems. GLOSAS Project advocates the use of systems dynamics. Systems dynamics models are customarily written in continuous systems simulation languages, such as DYNAMO, CSSL, ACSL, and CSMP. It is especially suited for the test of "what if" assumptions of various policy alternatives on long-term socio-economic behavior interactively and successively in the gaming mode.

Systems dynamics can also incorporate, by proper manipulation of the programming language, static methodologies such as input/output, mathematical programming, and cross-impact method, as well as statistical methods such as econometrics for short-term forecasting. GLOSAS Project also advocates the use of methodologies which take advantage of the involvement between policy-makers. The following communication-oriented methodologies are important;

(1) Policy Delphi (50) - useful in the development of parameters in large models by generating opposing opinions of experts.

(2) Cross Impact Matrix Analysis (53) - uses the interactive aspects of various decision-making processes with a group of experts to assess and evaulate the probabilistic uncertainties and impacts which the occurrence (or non-occurrence) of one potential future event has on the occurrence (or non-occurrence) of other potential future events.

7.4 Summary

The basic task of the computer in a gaming simulation is to simulate those aspects of the overall model which are not simulated by player activities. To this end, high level continuous and/or discrete simulation languages should be used so that updating of the status of the simulated system, list processing, statistics collection, and the generation of random variates, etc., can be performed easily by non-data processing professional participants. When the richness of a multiple participant game is desired, the computer-conferencing system can provide a communications and coordinating facility among geographically dispersed players.

Because gaming simulations are frequently changed and augmented, it is important that changes to one submodel require minimum alterations in other submodels of the simulation, and that new submodels can be added to the simulation with minimum disruption of the pre-existent simulation (75). The DCSS may well achieve this goal.

Each subsystem should possess the following characteristics and capabilities:

(1) an independent data storage area inaccessible to procedures in other subsystems;

(2) ability to communicate with other subsystems through a global storage area under the control of a simple and carefully defined protocol;

(3) control over the advancement of simulated time in the subsystem;

(4) facilities for defining and communicating with the game participants (or their roles) in the subsystems.

These facilities allow each subsystem in the overall gaming simulation to be developed and changed with minimal impact on the remainder of the simulation. If the gaming simulation is to have multi-disciplinary coverage, the computer component must not only include submodels from the relevant disciplines, but provide for substantial interaction between those submodels.

III. GLOSAS PROJECT

1. GLOSAS Project (63, 67)

Global Systems Analysis and Simulation (GLOSAS) Project proposes the development of an international peace gaming of energy, resources and environmental (ERE) systems over the newly established global computer communication networks (the so-called value added networks (VANs)), for the quantitative and predictive simulation study in certain types of the decision-makings within an international framework. It will become a part of a global decision support system (GDSS) which intends at its ultimate stage to provide decision-makers in the participating countries the impacts of possible policy-decisions of different countries and groups of countries on each other's ERE systems, domestic economies, as well as international trade and monetary systems.

The peace gaming will utilize integratively the distributed computer simulation system (DCSS) with distributed data base management and computer conferencing systems. The DCSS will replace the current mode of running a simulation on a single computer. Global simulation will then be carried out by running submodels of socio-energy-economic systems on computers throughout the world linked by the communication systems, thereby enabling the participants to interface collectively and execute simultaneously, interactively and cooperatively, the complementary models of the various countries and sectors to be considered, as parts of the total simulation required.

Such diverse modelling techniques as systems dynamics, input/output, linear programming, econometrics and cross-impact matrix methods will be employed where appropriate. Various data bases will also be constructed effectively around the network with the use of distributed data base management system, during the development of various simulation models.

During the gaming, computer conferencing makes it possible to emulate the real world communication and decision processes associated with the systems being modelled. In this way, the gaming activity becomes dynamic in nature, since it utilizes the expertise of the players to improve and enhance the modelling perceptions of participating nations, and hence the structure of the game. By providing a better intuitive understanding of a given problem situation and by leading participants through successive approximation to the construction of a realistic analytical model, the distributed, worldwide interactive peace gaming simulation is especially suited for the diagnosis and treatment of complex, conflicting socio-economic problems of foreign trade and tug of war of limited resources, by the participation of many experts.

The computer conferencing system also provides communications for coordination among the experts for the joint construction of models, for consultations and consensus decision-makings during the execution of interactive gaming simulation, and for the administration of this complex project. The consensus seeking should lead to a plus-sum (instead of zero-sum) approach to the decision-makings. The transmission of ideas between decision-makers and modelling experts and the dissemination of issues among decision-makers will be enhanced and accelerated by the computer conferencing system for the specification of model assumptions and structure, as well as the feedback of differences in judgement among the disscussants. A side-benefit will be the ultimate discovery of "invisible colleges" consisting of a communicating faculty of international scholars who will encourage and assist in the model-building so that a wider range of expertise can be brought to bear.

The initial stage of GLOSAS Project will be a joint undertaking of Japan and the United States, involving the forging of new dimensions of international and interdisciplinary cooperation in recognition of the interrelated, international character of today's problems and the notion that solutions to world problems lie in joint planning and application of the technologies and intellectual resources among nations. Primary consideration will be given to the critical role that energy plays in the world, as energy is the principal factor upon which modern society and human well-being rest. Further emphasis is also made on petroleum as the main source of energy. Consequently, typical submodels will be for crude petroleum production, world petroleum trade, and domestic economic and energy models.

The system integrating all of them will hopefully improve the international cooperation for setting worldwide energy policy and may become someday a practical means and tool for daily decision-makings. Spin-off benefits will also be enormous when such an integrated system is applied to other subjects.

2. Objectives

The research for the design of this project is necessarily complex. The objectives can be listed as follows:

(1) To establish a technological link between Japan and the United States (and later other countries) for rapid communication by utilizing the computer conferencing system via global public VANs.

(2) To develop appropriate interfacing protocol software so that part of a large model can be executed on seperate dissimilar computers geographically remote from each other (with each submodel possibly being executed in a different simulation language). These component models will then be able to perform some part of the total simulation required, interactively, cooperatively and simultaneously in computer-to-computer conversational mode via telecommunication lines. Execution outputs (graphical or tabular) or any part of total simulation should be available at will from any terminal.

(3) To develop a scheme such that the computer conferencing system can be used in conjunction with the interactive gaming simulation.

(4) To construct and subsequently interface appropriate simulation submodels of the supply and demand of energy and resources, and the environmental controls in relation to the structure of industries and socio-economic systems in Japan, the United States, the oil producing countries and the rest of the world, in order to jointly evaluate total energy policy of Japan and the United States combined.

(5) To conduct multi-national interactive peace gaming simulations of energy and related models via global VANs by experts of Japan and the United States for the prediction of the future courses of both countries and for the evaluation of appropriate policy-making needed to obtain appropriate consensus on various global energy issues.

(6) To provide arrangements for technical consultations and joint planning for the subsequent building, modifying and integrating of simulation models of other countries and sectors.

(7) To establish a permanent international management center for the organization and operation of the global computer conferencing system in order to promote the utilization of this technology by scientists and decision-makers throughout the world, and for use by existing or developing international projects in such areas as engineering, economics, biology, medicine and systems science.

This project then represents an engineering implementation and demonstration project on the development and construction of an interfacing protocol software necessary for a distributed computer system capability to support simulation activities. The primary application of the proposed interactive DCSS is the construction of large-scale socio-energy-economic models through the integration of smaller components which may be useful for policy analysis. The GLOSAS Project will not only help in providing solutions for the immediate problems facing mankind, but will also aid in establishing the foundations (technological, institutional and professional) for the long-range planning and international cooperation needed to assure world prosperity.

3. Methodology

For the sake of simplicity, the initial stage of the GLOSAS Project will emphasize the use of models, built in the systems dynamic methodology during the development of interfacing software necessary for the DCSS. This is because the systems dynamics approach for alternative forecasting and policy analyses has the following merits (13):

(1) Global social system is comprised of many diverse users, each responding in unique ways to various endogenous and exogenous stimuli. Understanding the complexity of system behavior stemming from this diversity requires characterization of the time-dependent and interactive information feedback properties of the various sectors (or country) of the global system.

(2) Because policy analysis applications entail evaluation of policy impacts in an uncertain future environment, it is desirable to be able to repeatedly test the validity of the model in terms of each of its internal behavior properties, not simply in terms of aggregate statistical comparisons.

(3) Acceptance of any model as a suitable aid in making policy decisions requires consensus among those affecting and affected by such decisions that the model does, in fact, adequately represent the cause-and-effect behavior of the global system.

At first, submodels will be constructed with a systems dynamics methodology by different continuous system simulation languages, such as DYNAMO III-F, CSMP-IV and ACSL, etc.. All of them are based on FORTRAN. The submodels stored in dissimilar computers will be interfaced by the global computer network for their simultaneous execution. Submodels written in FORTRAN and attached to those systems dynamics submodels will be executed automatically. Secondly, submodels written in FORTRAN, but stored in other computers, individually dissimilar, will then be interfaced by the computer network.

Subsequent phases of the GLOSAS Project will intend to create new solution methodologies by integrating the other conventional ones, such as econometrics, input/output method, linear programming, policy delphi, cross-impact matrix analysis, etc., with the DCSS.

4. International Cooperation on Descriptive Modeling

The GLOSAS project will forge ahead new dimensions of international and interdisciplinary cooperation and enhance the notion that the solutions to today's interrelated global problems lie in joint planning and application of the world's technologies and intellectual resources. Because of the realization of the (sometimes unavoidable) communication and data management problems which beset today's crises, the GLOSAS project envisions a distributed responsibility of participants in various countries and disciplines. Using (at all times) computer-assisted conferencing systems as a tool for planning, participants will establish compatible objectives, their inventory of global resources, and the time and cost constraints in order that scarce materials and services can be efficiently allocated. The project tends credibility to the development of a modern international planning process which can encourage the communications necessary for economic and political interdependence.

Furthermore, the international computer-conferencing dialogue can be made more rich by embedding descriptive models which depict the dynamics of a given scenario, and assist the participants in understanding the import of each other's statements and suggestions. It is hoped that by all participants having access to one common, integrated socio-energy-economic simulation system, the issues can be more readily defined, the relevant parameters easily adjusted, and the implications of international policy mutually tested.

Research will be carried out with university, industrial, and governmental participants to ensure the use of reliable data and the testing of relevant policy alternatves. Working teams of specialists in both countries, will conduct systems analysis and build models and data bases.

5. Procedures for Building a Global Decision Support System

5.1 Establsihment of U.S./Japan Data Communications Circuit

The establishment of global VANs is a necessity for the GLOSAS Project. Since its initial conception in 1972 (61), we have devoted our considerable time and effort (69, 71, 72), in cooperation with various communication authorities, to extend the U.S. public VANs to more than 35 major overseas countries and regions. The connection with Japan is the International Computer Access Service (ICAS) of Kokusai Denshin Denwa (KDD) of Japan. Those countries (excluding Japan) and regions already have a two-way, high speed linkage with the U.S. in such a way that a host computer in them can be accessed from the U.S.. An international invisible college can now be formulated with the use of computer conferencing system on the global VANs. This also makes possible the formation of DCSS.

The inauguration of ICAS may be called the first practical spin-off of GLOSAS Project benefiting Japanese marketing of many U.S. computer and information services and software products, such as SDC Search Service, Lockheed Information System, New York Times Information Service, etc..

Unfortunately, Japanese communications regulations do not currently allow the use of electronic mail and computer conferencing system available from host computers of the U.S. domestic public VANs through the ICAS. We have filed a petition to remove the restrictions to the U.S. and Japanese governments (74). The U.S. Commerce Department and Japanese Ministry of International Trade and Industry (MITI) are now working to resolve this issue (39, 40). When removed, Japanese experts will be able to join in GLOSAS Project with the use of a computer conferencing system via the ICAS. This second practical spin-off benefit of GLOSAS Project will be enormous to various sectors of society.

The establishment of a Public Service Host (PSH) in Japan and its international connection with the PSH of the U.S. CSNET, has been proposed for a two-way, high speed satellite data communication circuits with roof-top antennas, i.e., the so-called RAINBOW BRIDGE ACROSS PACIFIC (Figure 4). This third practical spin-off will also bring enormous benefits to various cooperative researches of both countries, such as Project LINK (worldwide econometric study) at Wharton

School of Economics of the University of Pennsylvania, International Research and Development of Fifth Generation Computer of MITI, the U.S./Japan Policy Research Institute proposed by a leading Japanese politician. We will also recommend to the U.S./Japan CSNET the appropriate computer conferencing modes, interactive simulation languages, partitioned data base management system, and higher level protocols which will enhance the use of their network.

5.2 Preparation and Design Phase

In this phase, leading experts will design the computing and communications interfaces for the complementary submodels of the ERE systems. Certain emphasis will be placed on the structure of interactive games and the management of gaming simulation's components (including the participants themselves).

Over a year period from the fall of 1982 when the funding warrants the project, experts will communicate with each other over the Electronic Information Exchange System (EIES), the most advanced computer-based human communication system at the New Jersey Institute of Technology, which provide them with asynchronous communication capability via the global VANs, through the convenience of their home or office computer terminal.

This computer conferencing will be initiated by the U.S. scientists and researchers. Japanese experts will then participate, as observers at the initial stage, by accessing the conference dialogues at EIES via the ICAS of KDD of Japan.

5.2.1 State-of-the-Art Review Phase

The 5 separate "sub-conferences" occurring simultaneously will review the state-of-the-art technologies for the peace gaming in the following areas having a few selected members in each group.

(1) High-level communications protocol software for interfacing application programs residing in dissimilar host computers of global packet-switching networks;

(2) Software protocols needed for distributed interactive computer simulation system, so that parts of a large model can be executed on separate, dissimilar computers geographically remote from each other, with each submodel possibly being executed in a different simulation language;

(3) Software protocols needed for distributed data base management systems, which allow for dispersed storage, access, and security of potentially large amounts of information;

(4) Distributed computer conferencing system as an aid in the multi-person design, implementation, and validation of simulation models, and in the conducting of interactive gaming simulation to obtain consensus (plus-sum game), and also for project administration;

(5) Interfacing of complementary socio-energy-economic models of various countries to obtain a total, comprehensive picture of complex relationships.

5.2.2 Design Phase

In the second part of this phase project, researchers will assemble the state-of-the-art technologies to develop the specifications of the interfacing software protocols and to design the DCSS for the peace gaming as the most reliable and comprehensive computer simulation method available to decision-makers.

Each of the five sub-conferencing groups will produce interim and final state-of-the-art review reports on their assigned technology fields, utilizing the advanced text composition spaces provided on EIES. The reports will show how to configure the integration of the latest technologies to achieve the goal of GLOSAS Project. Each sub-conference will also have the responsibility of producing final evaluation, analysis and design specifications of the DCSS and the interactive gaming simulation system covering the recommendations of its members. Interim reports from each conference will be supplied to other conferencing groups in preparation for the final stages, when the "wall" separating the five distinct groups will be "broken down" to allow for one convergent conference to address the vital issues and concerns that permeate the five conferences, i.e., a structure known as SYNCON (SYNergistic CONvergence) (50).

5.3 Future Steps for Subsequent Demonstration Projects

The effectiveness of the new, available, computer/communications technologies is to be demonstrated not only in coping with large, complex problems but also in establishing a "bridge" between the U.S. and Japan who wish to see a joint solution to the problems. An important step is the successful demonstration of the feasibility of the distributed, interactive computer simulation system. The demonstration must make a large-scale, multi-sector model written in continuous/event simulation systems, capable for interactive simulation in distributed computers. Furthermore, the demonstration must show the utility of the "peace gaming" simulation in resolving international problems involving many different, conflicting interests not by optimizing one objective selected among others, but by establishing consensus among the participating parties, i.e., not zero-sum but plus-sum approach. This should bring much credibility to the "global" problem-solving approach.

The following demonstration projects will be conducted subsequently with possible additional funds from the U.S. National Science Foundation, and others in the future. The ultimate goal of the multi-national policy analysis with distributed, interactive gaming computer simulation on global public VANs will be realized after many years' further arrangements.

5.3.1 First Phase Demonstration Project

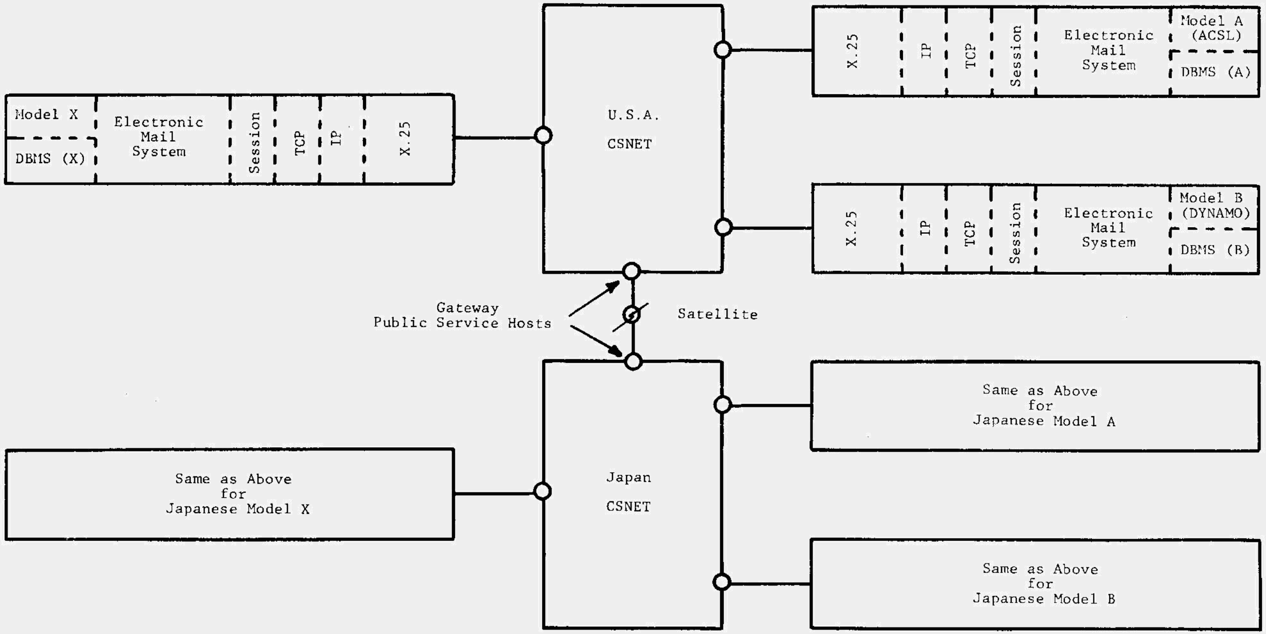
The newly established global VAN will make it possible for geographically dispersed dissimilar computers to perform distributed data processing (DDP). By definition, the DDP applied to simulation is the distributed computer simulation system (DCSS). This first phase demonstration project will develop the interfacing protocol software necessary for the DCSS with the use of TCP/IP high level protocols and virtual network file system mentioned before, according to the design specifications of the previous phase proejct. The interconnections among host computers of the U.S. and Japan packet-switching networks required for the DCSS may be depicted as shown in Figure 12.

Our thorough investigations of various systems dynamics socio-energy-economic simulation models concluded that the World Dynamics-II model (16) is simplest, though not rich, enough to be used as an example tool for the very initial development of the interfacing software necessary for the DCSS. During this phase, therefore, the World Dynamics-II model already programmed in a simulation language (with 5 component sectors) will be used. To this end:

(1) Execute (not interactively) models which are written in a single continuous system simulation language, say DYNAMO, but which component models are located in various distributed single type computers, say DEC computers, on ARPANET, using TENEX operating system (once used for McROSS system development by R. H. Thomas (54)) of the DEC computers,

Figure 12

Possible Interconnections
of
Higher Level Protocols and Distributed Computer Simulation System



(2) Transfer some of the component models to dissimilar computers on the ARPANET using the CCL and CCLP of virtual network file system,

(3) Convert some models with other continuous system simulation languages, such as CSSL, ACSL and CSMP (62),

(4) Make the languages capable for interactive simulation,

(5) Execute those models interactively, cooperatively and simultaneously,

(6) Develop a scheme in such a way that computer conferencing system can be used in conjunction with the interactive simulation,

(7) Prepare the schemes of the second phase demonstration project.

The following related fields also need to be concerned;

(1) High level data communication protocols,
(2) Continuous systems simulation languages,
(3) Operating systems of dissimilar computers.

Newly, established packet-switching data communication protocols, such as X.25, etc., are now available as an international standard of global public VANs. The interfacing software being developed is necessarily at higher level than the data communication protocol.

As mentioned before, this phase is based upon the notion of necessity of DCSS in order to simulate faithfully the mechansim of international socio-energy-economic systems. Consequently, the effort of this first phase demonstration project is to design a plan towards utilizing the necessary interfacing software, so that the next stages of model building and of interactive gaming multi-national policy analysis may well be undertaken by other researchers, who will be responsible for the specifications of data manipulation and model formulation, and explanation and interpretation of the socio-energy-economic systems.

The successful demonstration of this initial phase project will then show the feasibility of the distributed, interactive computer simulation system. Pioneering and constructing new basic tool of computer simulation with the use of globally distributed computer networks, this phase project may benefit simulationists of various fields, disciplines and countries.

5.3.2 Second Phase Project

This phase will test the protocol software and utilization plan developed by the first phase demonstration project, with the use of the existing models of energy economics of Japan and of the United States, and with agricultural economics models of the United States. The aim of this comprehensive simulation demonstration is the analysis of energy policy affecting the domestic and international economies of Japan and the United States.

Since the main purpose of this project is to utilize software which interfaces models written by various continuous system simulation languages, this phase will not attempt to create new models unless necessary. Rather, it will try to interface existing models developed elsewhere. Although certain models should be built by the experts of each country to increase credibility of the simulation results, this phase project will utilize mainly models built only by Americans for the sake of simplicity. However, the following models may be considered for this phase project:

Japan

(1) Reference (53); --- This model interfaced systems dynamics economy model with cross-impact probabilistics model for Japanese energy policy study.

(2) Reference (23); --- A Japanese economy model built by systems dynamics methodology with econometric consideration.

U.S.A.

(1) Reference (10); --- A probabilistic systems dynamics model about the U.S. agricultural economics.

(2) Reference (2); --- A systems dynamics energy model for interfuel competition study sponsored by NSF.

Oil Producing Countries

(1) Reference (65); --- This is a combination of Japanese systems dynamics economy model, a linear programming model for Japanese oil policy, and econometric models of oil producing countries.

5.3.3 Third Phase Project

Third phase is to demonstrate the technical feasibility and concept-strength of the joint U.S./Japan policy-making and evaluation. The protocol software tested during the second phase project will enable the interface of component models written in various simulation languages, and residing in dissimilar computers. These component models can then be executed as parts of the total simulation required, interactively, cooperatively and simultaneously in computer-to-computer conversational mode via the global public VAN.

Models of energy use, resource allocation, the national economy, foreign trade, international monetary systems, and environmental impacts will be built by interdisciplinary teams from Japan and the United States, interfaced by computer conferencing systems. For now this project will demonstrate such a DCSS enabling the collective and integrative use of models in the energy-allocation planning process. The domain of this phase is the supply/demand of energy and resources in Japan, the U.S., the oil-producing countries, and the rest of the world. The jointly developed evaluation procedures and models will also focus on environmental control within the constraints of present industrial and civil structures. The obvious reason for choosing the ERE sector is the criticality of this sector to the global perspective.

Research will be carried out with university, industrial, and governmental participants. Each team will conduct systems analysis, build models and data banks. In this phase, experts of Japan and the United States will be invited to interface their models, possibly by this time, with the use of the U.S./Japan CSNET (Figure 4), in order to perform internationally distributed, interactive "peace gaming" simulations of the global socio-energy-economic system for multi-national policy analysis. The experts will first design the computing and communications interfaces for the complementary submodels of the ERE systems written in various simulation languages and methodologies. These submodels reside in geographically dispersed, dissimilar computers. The approach is to focus on the global information system which is driven by the following:

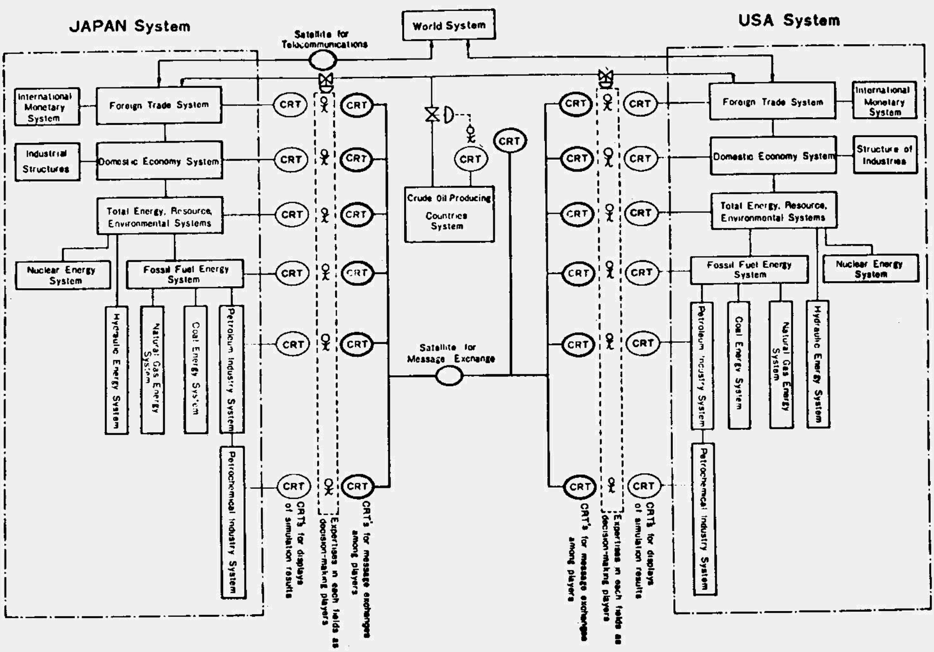
Global Public Computer Communications Networks,
Computer Conferencing System,
Distributed Data Base Management System,
Distributed, Interactive Gaming Simulation System.

The outline of the hierarchical structure and components of the integrated interactive peace gaming simulation system for the energy, economics, foreign trade, etc. on the United States and the Japanese sides are shown in Figure 13 (63). Each block in the figure represents dissimilar host computers of the public VANs in those countries. Those computers include simulation models designated in each block. All models will be executed simultaneously and concertedly via satellite and terrestrial telecommunication links.

The world dynamics model here is a kind of an executive main program, and will provide a common area through which the information of variables will be exchanged among the models of both countries. Accordingly, the flow of petroleum from oil produing countries will be regulated by their own decisions as well as by decisions made by the pseudo-decision-makers of both countries. The information on petroleum flow will be cascaded down from the foreign trade model to the petroleum industry model, which will be supplemented with the petrochemical industry model. The communication linkages are also shown in Figure 13 (63). These include (1) display units for showing simulation results to experts and pseudo-decision-makers in each field, and (2) display units for information exchange among them with the computer conferencing system which may be provided through computers other than the ones processing the simulation models.

Figure 13

Structure of Integrated Models and Communication Network



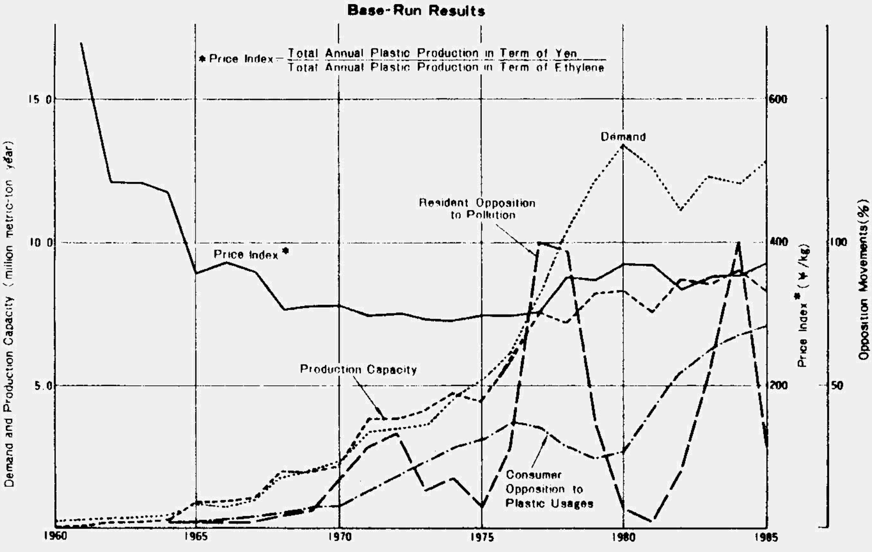
After interfacing the respective Japanese and the United States models, the GLOSAS Project proposes to conduct multi-national interactive gaming simulation in computer-to-computer conversational mode via the global computer network. Namely, after the simulation progresses for a time period, results will be shown on display units. For example, suppose if pollution in Japan exceeded a certain allowable level (Figure 14, (64)), the expert watching it on his display unit will stop the entire simulation. All participants, wherever they are located, will then try to find, with the use of the conferencing system, a consensus on a new pseudo-alternatve-policy parameters. New parameters will then be fed to simulation models which will be executed until a new crisis appears. The process will be repeated for the study of policy analysis with international cooperation of experts in both countries.

5.4 Interactive Global Peace Gaming Simulation

Global modelling and simulation studies have been conducted by various groups and institutions since early 1970s for enhancing the usefulness of international modelling (and policy-making) activities (7, 8). However, with the advent of

Figure 14

Growth of Japanese Petrochemical Industry



global VANs and standard interface protocols for interconnecting various dispersed, dissimilar host computers, the potential exists for ensuring the coordination of international efforts by providing more frequent communications and an environment for shared development, enabling more credible simulation study than ever before.

The global decision support system (GDSS) in GLOSAS Project is envisioned to evolve slowly. Ultimately, we will have in place a support system accessible to decision-makers in international agencies, corporations, and universities and which will accommodate their joint participation in the following steps of their planning process:

(1) Problems identification -- what sectors are affected?; is it a micro-level or macro-level problem?; what level of involvement is needed on the part of international decision-makers?;

(2) Selection of analysis mode -- e.g., top-down vs. bottom-up;

(3) Installation and maintenance of a disaggregated data base and virtual network filing system;

(4) Standardize reports to be generated periodically and procedures to query the data base for ad-hoc analysis;

(5) Communication among geographically dispersed decision-makers for enhanced insight and further localization of problem;

(6) Representation of historical data by statistical techniques such as econometric analysis of time series;

(7) Supplementary insight with the use of graphic and specially developed indices;

(8) Interdisciplinary model development by international experts - using various simulation techniques and languages to present models;

(9) Interactive gaming simulation with consolidated models for scenario-evaluation, and what-if analysis;

(10) Conferencing to discuss viable solutions depicted in the games and experiments to monitor future events.

After the successful completion of the previous demonstration projects between Japan and the United States, overseas experts in various disciplines and countries, such as Canada, Australia, European, communist, and developing countries will be invited to interface their models in computer-to-computer conversational mode via global VANs, in order to perform internationally distributed, interactive "peace gaming" simulation of global socio-energy-economic systems for multinational policy analysis.

As mentioned, the purpose of the interactive gaming mechanism is to help finding the appropriate global allocations of energy, food, natural resources, industrial structures, and shared technologies by establishing consensus among participating parties (instead of by optimizing one objective selected from others). It is suggested here that distributed computer simulations of global energy-economic activities be tested interactively with man (the decision-maker) in-the-loop for inserting pseudo-policy-parameters to the simulation models whenever necessary, during the execution of the simulation model. This is the so-called "peace gaming" simulation (66) similar to the "war games" practiced by military strategists (51).

The following steps then could be taken:

(1) Establish small project teams of highly skilled computer simulationists who analyze social systems in each country.

(2) Contract with an organization which supplies computer conferencing services through the U.S. public VANs. The services should be accessible from major overseas countries.

(3) Conduct systems analysis of a subject area by teams using the global computer conferencing system;

(4) Construct crude simulation models of each country with selected computer languages and methodologies. The models can be constructed and debugged individually at the initial stage with computers located in each country, but their interface capabilities should be designed to coincide for future consolidation;

(5) When any participating country does not have experts in the above mentioned fields and methodologies, nor computing facilities, invite appropriate experts and have them construct the models for the country;

(6) Plan the utilization of standard software of DCSS which will include various protocols, commands, handshaking procedures, common data bases, display procedures, message exchanges, etc..

(7) Once every country's models have been constructed, aggregate the models using the global computer network. The total model should be operational in interactive mode for the global policy analysis, allocating appropriately international crude oil flows.

Other similar simulation models will be used, again as example tools, to improve the versatility of the interfacing software, so that the software may be utilized by other researchers who may wish to explore in the future the approach of the DCSS in various fields on a domestic or international scale.

6. Anticipated Benefits and Users

6.1 Spin-Off Benefits

The protocol software to be developed by GLOSAS Project can be used for distributed processing in a variety of fields with the proliferation of micro- and minicomputers. The protocol software may also lead to effective utilization of computers around a distributed computer network, in which computer-specialized software will reside. Consolidation and conservation of computer hardware and software, man-power, financial resources with reduction of duplicating efforts for cost saving through joint coordination, may be brought with the applications of the distributed processing, simulation and conferencing technologies.

The interactive gaming nature of DCSS will be a helpful tool for decision-makers of many fields, such as decentralized corporate management. The extent of the public VAN in global scale will also make it possible to apply such gaming simulation to the analyses of multi-national corporations and international economy. For example, multi-national corporation decentralized with the spread of the global VANs may be assisted with the integration of management simulation models by the DCSS. Simulation models of various divisions and operations of urban community may be integrated with the use of the DCSS. State-wide individual energy models may be integrated with the federal level energy models. Interactive gaming approach may also be useful for the analysis of inter-state energy movements (76). The establishment of distributed data base management system is also in the current trend in federal, state and municipal governments, multi-national corporations and organizations, etc..

6.2 Application to Education

The U.S. and Japan will gain sufficient planning experience to engage in computer-assisted crisis management through the integrated use of computer conferencing and quantitative, predictive DCSS, and then be able to enjoy rich methods of communications that will offer them deep understanding of each other's socio-economic institutions.

The interactive global peace gaming system may also be utilized for personnel training and education in international affairs and economics, political science, etc.. Integrated use of global VANs coupled with computer conferencing and computer assisted instruction systems may provide globally distributed learning system (GDLS), as encouraging interactions among educational institutions. Dispersed groups of students and faculty will be able to access new scientific and cultural discoveries as they are developed.

Side benefits of this interconnections among computers of educational facilities in various countries is to provide international resource sharing, such as computing power, various information and application programs, communication facilities, etc., with less cost in the U.S. to other countries' universities, due to time differences between the U.S. and most overseas countries, and also at the same time, as providing the U.S. computers with load-leveling and economy-of-scale benefits.

6.3 Anticipated Users

Possible users of the interactive "peace gaming" simulation studies are various national and international organizations, such as United Nations, UNESCO, U.N. University, OECD, IMF, World Bank, International Energy Administration, multinational corporations, etc.. Besides their possible participations in the peace gaming of the various topics, the gaming results will be published in conferences and professional journals, or as the newsletters to them. The participating and contributing organizations will also be furnished with comprehensive reports of each interested games. They will then increase the value of the global remote sharing of computer resources, thereby promoting cultural exchange and improving standards of industry, economy and living in various countries.

IV. CONCLUSION

The global problems facing us now urge the extending of their geographic and disciplinary boundaries to include the close interactions of foreign trade, national resources allocations, environmental control, and even political international relationships.

Computer simulation on a worldwide scale is an increasing necessity. But such large-scale computer simulation cannot become practical unless it utilizes multiple computers linked with a communication network, and unless multiple working teams scattered around the world exchange their knowledge and data resources through a computer-based conferencing system. Different parties should construct simulation models of their regions. Such models should be tied together by means of distributed computer simulation system (DCSS) to study their interactions and influences on a truly global scale.

The DCSS will enable to interface component models written in various simulation languages. The models will reside in geographically distributed dissimilar computers. These component models can then be executed as parts of the total simulation required, interactively, cooperatively and simultaneously in computer-to-computer conversational mode via the global public VAN. The DCSS will produce a more reliable and comprehensive computer simulation study than ever before. Its interactive gaming nature will be a helpful tool for decision-makers of many fields, such as decentralized multi-national corporate management, international socio-energy-economies, etc..

Computer-based conferencing may create an "Invisible Global Research Institute", gathering world experts whenever they desire and are available for the integrated use of their "brainware" for the benefit of mankind. Such an interfacing of experts and computer models of all countries may correspond to the establishment of an "Electronic United Nations".

It is now a vital necessity for scientists and simulationists to cooperate not only interdisciplinarily but also internationally in order to plan ahead for the establishment of interactive peace gaming simulation system for global policy analysis and makings. Global collaboration of social and technical experts is now possible in economic, technical and practical terms. Its development is important and timely. What we must now do is to establish suitable ground rules, reasonable assumptions, and a common set of premises for the various modellers to work from. Such teamwork among computer simulationists will promote a new form of peaceful collaboration among nations.

The antinomy of totalitarianism is democracy, where responsibility is taken by each individual. In the former control is centralized, in the latter it is distributed. The same principle and approach can also be applied to the computer simulation of social systems. With the use of a single computer and a simulation language, the totalitarian or centralized control is inevitable. The advent of distributed computer network can however allow the realization of the democratic approach of computer simulation. The global information network of the GLOSAS Project will be created by various experts in every country with their distributed responsibilities. Hence, its spirit is a truly democratic manifestation which has been longed for by computer simulationists (51), and the potential good therefrom by peoples of the world.

The anticipated spin-off benefits out of this GLOSAS Project will be many folds, in education, medicine, agriculture, science and technology, economics, etc., to name but a few. These benefits will be to the developed as well as to the developing countries. Cooperation to share valuable resources of communication facilities, computing hardware power and software services and even of peoples' "brainware" is the basic principle and condition of this project.

V. ACKNOWLEDGEMENT

The authors express their gratitude for the cooperation and constructive suggestions given by the members and associates of the GLOSAS Project in various countries. Special thanks are also due to the staffs of Graydon Associates, Inc., in Red Bank, New Jersey, for their typographic assistance.

VI. REFERENCES

(1) Barna, B.; "A New Threat to Multinationals"; Computer Decisions, August, (1978), pp. 34 to 38.

(2) Baughman, M. L.; "Dynamic Energy Systems Modeling - Interfuel Competition"; Energy Analysis and Planning Group, Massachusetts Institute of Technology, September, (1972).

(3) Becker, H. B.; "Distributed Data Processing: Where We are Now"; Data Communications, August, (1978), pp. 77 to 90.

(4) Blanc, R. P. and J. F. Heafner; "Off-the-shelf solutions motivate NBS's standards drive"; Data Communications, March, (1982), Pages 223 to 229.

(5) Boehm, B.; Keynote Speech at 1975 Summer Computer Simulation Conference (SCSC), San Francisco, California.

(6) Canning, R. G; "Soon: Public Packet Switched Networks"; EDP Analyzer, Vol 13, No. 2, February, (1975).

(7) Clark, J. and S. Cole with R. Curnow and M. Hopkins; "Global Simulation Models"; John Wiley & Sons, (1975).

(8) Cundiff, W.; "Modeled World Futures: Aspects of a Cybernetic Approach to Global Order"; Faculty of Environmental Studies, Student Discussion Paper No. 4, York University, Downsview, Ontario, Canada, February, (1977).

(9) Data Communications, July, (1980), Page 38.

(10) Donahue, C. J.; "A Hybrid Probabilistic System Dynamics Model of United States Agriculture"; Paper presented at 1976 SCSC, Washington, DC..

(11) Donovan, J. J., et al; "An Experimental VM/370 Based Information System"; Sloan School of Management of MIT, (1974).

(12) Drews, W. P.; "Research Results Needed for Energy Policy Studies"; Energy Modeling Workshop at Queen Mary College, London, October, (1973), pp. 163 to 170.

(13) Duffy, M. A., G. L. Eiden and C. W. Hamilton; "General Aviation Dynamics"; Battelle Columbus Laboratories, Columbus, Ohio; no date.

(14) Duke, R.; "Gaming: The Future's Language"; Halsted Press, New York, (1974), Page 18.

(15) Folts, H. C.; "Coming of Age: A long-awaited Standard for heterogeneous nets"; Data Communications, January, (1981), Pages 63 to 73.

(16) Forrester, J.; "World Dynamics"; Wright-Allen Press, Cambridge, MA, (1972).

(17) Goodman, F. K. and G. E. Juras; "NUCLEUS: A Simulation and Modeling System Applied to Demographic, Economic, and Electricity Demand Forecasting Problems"; Battelle Columbus Laboratories, Columbus, Ohio; no date.

(18) Goodman, F. K. and G. E. Juras; "Machine Independent Simulation Modeling"; 1978 Winter Simulation Conference Proceedings.

(19) GTE Telenet Report, Vol. 7, No. 3, June, (1980).

(20) Hammer, C.; "Computer, Communications and Man"; Luncheon Address at American Institute of Industrial Engineers Conference, January 21, (1976), Washington, D.C..

(21) Helmer, O. and N. Dalkey; "An Interactive Global Economic Model"; Simulation, December, (1977), Page vii.

(22) Hiltz, S. R.; "Computer Conferencing: Assessing the Social Impact of a New Communications Medium"; Technological Forecasting and Social Change, 10, 225 - 238, (1977).

(23) Hori, H.; "Dynamic Properties of a Japanese Macro-Economic Model and Effect of Exogenous Shocks"; 1973 SCSC Proceedings, Page 1016 to 1025.

(24) Hovey, R. B.; "The user's role in connecting to a value added network"; Data Communications, May/June, (1974).

(25) Information Technology News; "Electronic Mail System Runs On and Links Variety of Computers"; March 15, (1981), Page 13.

(26) Kupperman, R. H., R. H. Wilcox and A. Smith (The U.S. Arms Control and Disarmament Agency); "Crisis Management: Some Opportunities --International emergency cooperation involving governments, technology, and science is now foreseeable."; Science, Vol. 187, February 7, (1975), Page 404 to 410.

(27) Lipinski, H., R. Amara and K. Spangler; "Communication Needs in Computer Modeling"; 1978 Winter Simulation Conference Proceedings, December, (1978).

(28) Lipinski, H., R. Plummer and K. Spangler Vian; "Interactive Group Modeling: Part 1. Extending Group Communication Through Computers"; Institute for the Future, Report R-44, August, (1979).

(29) Lipinski, H., K. S. Vian, S. Spang and J. Tydeman; "Interactive Group Modeling: Part 3. HUB and The Modeling Process"; Institute for the Future, Report R-46, August, (1979).

(30) Lipinski, H., S. Spang and J. Tydeman; "Supporting Task-Focused Communication": Institute for the Future, Paper P-83, June 15, (1980).

(31) Lipinski, H. and S. Spang; "Communication in Interactive Simulation"; Paper presented at 1980 Winter Simulation Conference, December 3 to 5, (1980).

(32) Lipinski, H. and R. Adler; "Extending Electronic Communication to Support Group Problem Solving"; Institute for the Future, no date.

(33) Marks, H. E.; "Crossborder data nets become targets of European law makers"; Data Communications, September, (1978), pp. 67 to 76.

(34) McKendree, J. D.; "Project and Crisis Management: Applications of Computerized Conferencing"; Bulletin of the American Society for Information Science, Vol. 4, No. 5, June, (1978), Pages 13 to 15.

(35) McLeod, J.; "Simulation Today - and Yesterday"; Simulation Today, No. 1, p. 3 (appearing in Simulation, Vol 18, No. 5, May (1972)).

(36) McQuillan, J. M. and D. C. Walden; "Electronic Mail Systems: The Software Connection"; ICP INTERFACE (Administrative and Accounting), Spring, (1981), Pages 20 to 25.

(37) Miller, R. H.; "Computer Conference and Computer Mail: Impact on Today's and Tomorrow's Office"; 1978 IEEE, pp. 57 to 62.

(38) Moulton, J.; "Draft Report: Common Command Language Feature Analysis"; Prepared for Institute for Computer Sciences and Technology of the U.S. National Bureau of Standards; Report No. ICST/HLNP-80-4; System Development Corporation, June 6, (1980).

(39) Nihon Keizai Shimbun (Japan Economic Journal), December 8, (1981).

(40) Nihon Keizai Shimbun (Japan Economic Journal), January 8, (1982).

(41) Noel, R. C.; "Computer-Augmented Gaming and Simulation in International Relations"; Political Institutions Simulation (POLIS) Laboratory, University of California at Santa Barbara, California, June, (1972).

(42) Noel, R. C. and T. Jackson; "An Information Management System for Scientific Gaming in the Social Sciences"; 1972 SJCC Proceedings, pp. 897 to 905.

(43) Norman, A. R. D.; "The Regulation of Transnational Data Flow"; Impact (R810301), Arthur D. Little Decision Resources, Cambridge, MA., March, (1981).

(44) Postel, J.; "DOD Standard Internet Protocol"; Information Sciences Institute (ISI), University of Southern California (USC), Marina del Rey, CA, 90291, IEN 128, RFC 760, January, (1980).

(45) Postel, J.; "DOD Standard Transmission Control Protocol"; ISI, USC, Marina del Rey, CA, 90291, IEN 129, RFC 761, January, (1980).

(46) Postel, J.; "TELNET Protocol Specification"; ISI, USC, Marina del Rey, CA, 90291, IEN 148, RFC 764, June, (1980).

(47) Postel, J.; "File Transfer Protocol"; ISI, USC, Marina del Rey, CA, 90291, IEN 149, RFC 765, June, (1980).

(48) Riley, W. B.; "Seven-level architecture formalizes network protocols"; Electronic Design, September, (1981), SS-12 to 13.

(49) Roberts, L. G. and B. D. Wessler; "Computer network development to achieve resource sharing"; 1970 SJCC proceedings, pp. 543 to 549.

(50) Scher, J. M.; "Communication Processes in The Design and Implementation of Models, Simulations and Simulation-Games: A Selective Review and Analysis, from The Vantage Point of Computerized Conferencing"; Computerized Conferencing & Communication Center at New Jersey Institute of Technology, Research Report No. 4, (1975).

(51) Schram, S., H. Marks, W. Behrens, G. Levin, and J. McLeod, et al; "Macro-System Simulation"; Panel Discussion Session at the 1971 SCSC (Appeared on pp. 1491 to 1502 of 1972 SCSC Proceedings).

(52) Smith, J. P. and P. Moulton; "Telenet, Tymnet: what the difference is"; Data Communications, October, (1978), pp. 67 to 76.

(53) Stover, J. G.; "Energy Policy Modeling with Probabilistic System Dynamics: A Japanese Case Study"; Paper presented at 1974 SCSC, Houston, TX, July, (1974).

(54) Thomas, R. H. and D. A. Henderson; "McROSS: A Multi-computer Programming System"; 1972 SJCC Proceedings, pp. 281 to 293.

(55) Turoff, M.; "Conferencing via Computer"; Information Networks Conference NEREM, (1972), pp. 194 to 197.

(56) Turoff, M.; "'Party-Line' and 'Discussion' Computerized Conference Systems"; 1972 International Conference on Computer Communication, Page 161.

(57) Turoff, M. and S. R. Hiltz; "Meeting through your computer: Information exchange and engineering decision-making are made easy through computer-assisted conference"; IEEE Spectrum, May, (1977), Pages 58 to 64.

(58) Turoff, M. et al: "Person-to-Person Networks: Human Communication and Information Exchange via Computer"; Bulletin of the American Society for Information Science, Vo. 4, No. 5, June, (1978), Pages 9 to 23.

(59) Turoff, M. and S. R. Hiltz; "Computerized Conferencing: A Review and Statement of Issues"; New Jersey Institute of Technology, no date.

(60) U.S. National Science Foundation; "CSNET Report"; June 23, (1981).

(61) Utsumi, T.; "Global Gaming -- Simulation with Computer Communication for International Cooperation"; Paper presented at 1972 International Conference on Computer Communication, Washington, D.C., October, (1972).

(62) Utsumi, T. and Y. Shindo; "CSMP-III Simulation of World Dynamics-2"; bit, Kyoritsu Publishing Co., Tokyo, June, (1973).

(63) Utsumi, T.; "Joint USA/JAPAN Project on Global Systems Analysis and Simulation (GLOSAS) of Energy, Resources and Environmental (ERE) Systems"; Proceedings of the Conference on Energy Modelling and Forecasting, Berkeley, California, June 28 to 29, (1974), pp. 121 to 144.

(64) Utsumi, T.; "Japan Petrochemical Industry Model for the GLOSAS Project"; 1974 SCSC Proceedings, pp. 318 to 325.

(65) Utsumi, T., R. Ohkuma and T. Sumita; "Preliminary Study on International Oil Energy Policies"; 1975 SCSC Proceedings, pp. 1371 to 1380.

(66) Utsumi, T.; "Peace Game"; Simulation, November, (1977), Page 135.

(67) Utsumi, T.; "Need for a Global Information System"; Proceedings on Conference on Information Societies: Comparing the Japanese and American Experiences; International Communication Center, School of Communications, University of Washington, Seattle, December, (1977), Pages 79 to 83.

(68) Utsumi, T.; "GLOSAS Project"; Paper submitted to International Conference on Trans-national Data Regulation, Brussels, Belgium, February, (1978).

(69) Utsumi, T.; "Synopsis of GIS"; Global Information Services (GIS), Inc., New York, (1978).

(70) Utsumi, T.; "International Marketing Mechanism of Computer Information Services"; Paper presented at the International Conference on Transnational Data Regulation, Brussels, Belgium, February, (1978).

(71) Utsumi, T.; "Recommendation to Approve"; Petition submittted to the U.S. Federal Communications Commission (FCC), GIS, New York, April, (1979).

(72) Utsumi, T.; "Petition to Deny"; Petition submitted to the U.S. FCC, GIS, New York, February, (1980).

(73) Utsumi, T.; "ICAS & DDX-PS of Japan"; Newsletter (GIS-006-1980); GIS, New York, June, (1980).

(74) Utsumi, T.; "Petition to Remove Immediately ICAS Usage Limitations"; Petition submitted to the U.S. FCC, GIS, New York, August, (1981).

(75) Van Houweling, D. E.; "The Interactive Gaming Simulation Language: An Introduction"; 1975 Winter Simulation Conference Proceedings, pp. 363 to 367.

(76) Wall Street Journal; "High Court to Hear Two Cases Involving Interstate Fights Over Energy Resources"; October 11, (1978), Page 4.

(77) Wolf, E. W.; "An Advanced Computer Communication Network"; Paper presented at the AIAA Computer Network Systems Conference, Huntsville, Alabama, April 16 to 18, (1973).