GLOSAS PROJECT
(GLObal Systems Analysis and Simulation)

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GLOSAS Project proposes the development of an international peace gaming simulation 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 co-operatively, as parts of the total simulation required.

ABSTRACT

"The great object of science is to ameliorate the condition of man, by adding to the advantages which he naturally possesses."

Elements of Natural Philosophy, 1808

Art of science is collaboration which can help today's policy-makers confronting with acute global problems.

GLObal Systems Analysis and Simulation (GLOSAS) Project with special emphasis on the problems of energy, resources and environmental (ERE) systems, intends to provide decision-makers in the participating countries with comprehensive information within an international framework. Impacts on domestic economies, international trade and monetary systems will be included.

The newly established global public packet-switching computer communication networks via satellite telecommunications will be effectively utilized for the quantitative and predictive computer simulation study on certain types of the decision-makings as to the relation of energy, resources and environment to macro- and micro-domestic economies and industries.

Global simulation will be carried out by running submodels of socio-energy-economic systems on computers throughout the world linked by the communications system. The distributed computer simulation on a global computer network will interface and integrate bits and pieces of existing simulation submodels of various fields and countries, in order to minimize unnecessary expenditures of time and effort on new grass-root, analysis and modelling of component systems. Typical submodels will be for crude petroleum production, world petroleum trade, and domestic economic and energy models. 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.

The models will permit input of policy-makers' decisions via interactive terminals. Thus an interactive gaming situation for alternative scenarios will exist whereby the results of policy decisions or strategies formulated in different countries could be exhibited. The use of the distributed, worldwide

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interactive peace gaming simulation may well contribute to the solution of the conflicting problems of foreign trade and tug of war of limited resources, by the participation of many experts of various disciplines and countries.

The computer conferencing systems also provides communications among the experts for the joint construction of simulation models and for consultations and consensus decision-makings during the execution of interactive gaming simulations.

The system integrated 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 for such an integrated system applied to other subjects.

I. INTRODUCTION

All people of our world have suddenly been brought together into close physical contact with one another, forming a single "Global Village", by the astonishing modern achievements of transportation and communication technologies. These technologies regarding global crises now impinge more immediately, more vividly, and more swiftly on each individual than at any other time in history. Our world on a space-ship earth, with limited natural resources, is now shrinking with accelerated speed.

We live now, henceforth, in a world in which political and ideological ideas have become of less importance than scientific and technological facts, because of new and strengthening forces operating across all national boundaries. Global computer communication networks now provide cultural experiences shared by all people in a manner unparalleled in human history. Thus a common culture environment is being diffused worldwide, bringing many benefits to all aspects of our life.

On the other hand, 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 how different major policy-decisions of individual countries and groups of countries will affect both the internal structures of their economies and the flow of trade in goods and hard currencies among their economies before these policies are changed.

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 participative countries.

II. GLOBAL PROBLEMS

1. Global Interdependence

Worldwide inflation and recession facing us today underline the growing interdependences of every country's economic behavior with events on a global scale.

For example, if the United States government intends to suppress oil consumptions by raising gasoline tax, Americans will prefer to purchase automobiles giving excellent mileage which come mostly from Japan. (Japanese cars have already surpassed the market share of Volkswagen in the U.S..) This result from a cause in a different but related industry stimulates automakers in Japan, which in turn stimulates Japanese steel industry imports more coking coal from U.S., which consequently reduces employment of the labor force from the automobile industry in Detroit.

On the other hand, if these global phenomena were observed from the moon, the amount of steel used in Japanese made car purchased by Americans would have consumed some energy material, i.e.,

(1) to transport coking coal from east coast of the U.S as leaving land damages, through Panama Canal, across Pacific Ocean, then to Japan, as coal's ash causes pollution in Japan;

(2) to transport iron ore from Australia across Pacific Ocean to Japan, as sludges of the ore is dumped into Japanese coastal area;

(3) to transport the finished steel or automobiles from Japan, across Pacific Ocean, back to the U.S..

Another example is that, since high technology products, such as jumbo jets or computers, of the U.S. have limited world markets, the U.S. needs to earn hard currencies by exporting agricultural products, which consume large amount of energy, fertilizer and petrochemicals, in order to compensate the currency drain due to the ever continuing import of high priced crude oil from the Middle-Eastern countries. Japan imports almost 70% of her food consumptions as wheat and soybean mostly from the U.S. and Canada. Not only Asians but also many hungry nations throughout the world depend on the surplus food produced in the U.S. and Canada.

Another example is that, Japan is the leading country in Asia on the production of fertilizer, as some of which causes mercury poisoning problem during hydrogen production process by electrolysis of water. A large portion of the Japanese made fertilizer is to be exported to highly populated and hungry countries like India and in South-Asia, in order to accelerate high crop by the Green Revolution which may become a remedy to feed their explosively increasing population.

The production of fertilizer in Japan is mainly made from crude oil imported from the Middle-Eastern countries. When the crude oil price increases, the price of fertilizer also increases, prohibiting its import from Japan by the South-Asian countries, since most of the countries possess only meager foreign currencies. This in turn causes the need for food aid from the U.S., thereby increasing the food price which also causes inflation in the U.S..

Another observation may be made in the form of a warning: Japan does not have substantial energy resources, and imports almost 80% of her total energy consumption as crude oil from the Middle-Eastern countries. In the past, Japanese economic activity grew at a phenomenal rate while low priced crude oil was available.

It is, however, now a common to expect the depletion or, at least, the decline of production of crude oil in the Middle-Eastern countries within the coming 30 to 50 years. If then no alternative energy sources are available in sufficient quantity, though the prospect is very slim with the present state of the arts or technology, and also if new sources of energy will not be promptly discovered and ready for economic use, the collapse of Japanese economy may well be inevitable.

Also, since about 30% of Japanese export comes to the U.S. and about 30% of the American export goes to Japan, the collapse of Japanese economy may cause the economic domino of the collapse of the economies of America, European countries, and hence of the free world.

2. Energy Crisis -- The World's Foremost Problem

Since Prometheus, history of energy dependency of mankind is long. Every cheap available energy source has been explored and being used, since energy is the fundamental necessity to human life.

The most critical problem facing the nations of the world today is the diminishing availability of energy relative to demand. The oil crisis, resulting from the October 1973 Mideast war, vividly demonstrated the vulnerability of the world's economic system to significant decreases in the supply of energy. In the twenty-year period from 1960 to 1980, it is estimated that the worldwide consumption of per capita energy will have doubled. Today, Japan alone is importing almost 1.6 billion barrels of oil annually, a figure matched by the U.S. (1970), and it is estimated that a three- or four-fold increase in importing crude oil in the next ten years lies ahead for both countries. Such energy consumption levels by these two countries will exceed the total gross volume of oil produced by the Near and Middle-East countries, even without considering the future consumption rates of European and developing nations.

The result will be energy shortfalls, economic stagnation and possibly economic warfare if sound planning and worldwide policy-making are not undertaken. Simply put, the energy crisis will not disappear of its own volition and harsh reality dictates that the best joint efforts of all nations is needed to tackle the problem.

3. Natural Resources and Environmental Problems

Realistic global policy-making should also take into account the limits which the factors of natural resource availability and environmental absorption capacity impose. The problem of meeting growing demand for products cannot continue to be met by the traditional methods of discovering and exploiting new sources of raw materials. Reserves of oil, copper, bauxite, and other essential resources are already under heavy strain due to growing demand (the situation also being confounded by the growing sentiment in producing states to conserve reserves and/or sell at a higher price). In addition, the increase in the destruction of the environment (air, land and water pollution) is becoming a more important factor in calculating the "cost" of increasing consumption.

Most environmental problems, however severe, are local phenomena, except such one once existed about radioactive fallout due to atmospheric nuclear test which fallout traveled around the globe. The problems relate with urbanization and industries, and hence with national economy, which are also related with those of other countries. Consequently, the environmental problems at large are global problems.

For example, about 30% of energy is converted into electricity, and the other 70% is given off into energy sinks such as air and water. Local thinking concentrates on the 30% and believes that the sinks can absorb the excess; industry does not feel responsible for the deterioration of energy sinks. Namely, most environmental problems are mainly caused, directly or indirectly, by abuse of energy (e.g., air and water pollution by industries) or by mis-management of obtaining energy (e.g., land damages of coal mine industry), etc..

It is then that environmental problems, especially when it is perceived in global scale, should be considered as the resultant phenomena caused by energy, which relate with resources, industrial structures, national economy, foreign trade and international monetary systems.

Under these circumstances, a cooperative global policy shoud be established to foster efficient resource utilization for both consuming and producing countries and to structure industrial organization on a global basis to safeguard the environment.

4. World Trade and The International Monetary Problems

The energy crisis has also brought into sharp relief the necessity of developing a global approach to the problems of the international monetary systems and world trade.

As a result of the large increase in the price of oil, enormous sums of gold, dollars, yen and other hard currencies have flowed into the oil-producing states, giving those states greatly increased influences over the international monetary system and world trade. As prices have climbed higher and inflation has grown, the strengths of the major currencies have dropped, creating a liquidity crisis which could have significant adverse effects on international trade especially as consuming states find it more difficult to pay their bills and producing states bargain to increase their share of "added value".

Since trade, monetary reserve and resources influence one another, they should be viewed within a total system, with quantitative, comprehensive analysis and policy determination.

III. FUNDAMENTAL CONCEPTS FOR SOLUTION OF GLOBAL PROBLEMS

1. National Economic Planning

Concern about the instability of economy and the failure of short-term remedies to deal effectively with inflation and unemployment has generated in various countries a movement to require rational economic planning at the national level. The plan would establish economic objectives, with particular attention to attaining full employment, price stability, balanced economic growth, an equitable distribution of income and certain other goals. It would identify the requirements for achieving such goal and recommend necessary legislative and administrative actions with regard to money supply, national budget, interest rates, taxation and so on.

Families, small and large business and institutions all plan their economic activities. The complex national economy cannot be dealt with haphazardly; piecemeal legislative or administrative action designed to solve one problem often creates another (the so-called Forrester's law (5)). Economic planning would not give government any new powers to regulate or direct the economy, but the plan would be responsive to public opinion. Such a plan not only would rationalize the government's economic activities but also would make economic policy explicit and expose it to much broader public debate and control than at present.

2. Need to Global Strategies (76)

The interdependent nature of present human society demands that proposals for the future give attention to global strategies. Although right and value of political, economic, and social diversity should be remained, certain fundamental global structures and actions can and must be implemented if the quality of human life is to be improved. For regardless of how one envisions the specifics of a new world order, there is growing acceptance of the need for strategies of change beyond just national and regional scales. The global setting in which these macro strategies must occur is characterized by several conditions. One is that the nation-state, in spite of its numerous short-comings, will persist for some time as the dominant unit of world political organization. Consequently, global strategies of change will be forced to respect national sovereignty. Secondly, present world interaction patterns reveal in numerous nations a serious value and priority separation between the ruling powers and the masses. This separation is often exacerbated by a closer harmony of interests between the center in one nation and the center in another nation rather than between the center and periphery of the same nation. Global strategies need to respond directly to this phenomenon. And thirdly, global interaction is now predominantly economic, with politics and culture increasingly subordinated to perceive economic theory and interests. Thus global strategies of change need to point toward a new international economic order.

The major dilemma usually confronting proposals of fundamental global change stems from the ineffectiveness of enforcement structures. How to accomplish international strategies and still allow full national sovereignty becomes a problem of seemingly insurmountable proportions. Nations strong in economic, political, and technological power can simply refuse to alter their environmentally damaging policies, and the majority of the world has no resource but to acquiesce. The United Nations, although valuable as a beginning step toward international communication and cooperation on global concerns, is only minimally effective in implementing most of its change strategies, regardless of how positive many of these programs seem to be.

3. Importance of International, Interdisciplinary Perspective on Global Problems

The energy crisis (as well as problems of pollution, resources depletion, the international monetary systems, foreign trade, and national economies) is not the result of a simple, short-term disturbance in the international economic system, but rather is a reflection of fundamental shortcoming of that system. The underlying principle, heretofore, has been that individual nations had it within their power to control the direction of their economies and to minimize the adverse effects emanating from any outside sources. The wisdom, however, of that perspective has been thrown in doubt by the inability of nations to control inflation and to acquire resources for their economies (at least at the old prices). Given the additional circumstances of limited resources in the world and growing demand due to explosive population increases as well as worldwide higher expectations regarding the quality of life, the interrelated nature of the economies of the world's nations must be recognized as the basic factor in economic planning if the current problems are to be overcome.

The old approach of individual states pursuing their parochial interests in a "zero-sum" struggle for resources must be replaced by a new approach based upon international cooperation and interdisciplinary coordination. To do less would be to fail to properly recognize the nature of the problem and lead to less than satisfactory results.

4. Need of Well Organized Plan for Efficient Use of Depleting Old Energies

Many technical reports and policy recommendations on energy currently focus upon the production of new alternative energy sources. Since new alternative energy sources are difficult to come by in the near future, it is vitally necessary to focus our attention first on the efficient use, i.e., the conservation of energy from old sources, oil, gas and coal, before they are depleted from the earth.

Splitting the atom seemed to hold forth the promise of almost inexhaustible energy thirty years ago, but the promise keeps receding into the future. Since it has proved impossible to dispose safely of radioactive wastes, atomic energy as a source of abundance has become as frustrating as the magical touch of King Midas. The failure of the promise of nuclear energy indicates the ever importance of precious crude oil, and also urges its well planned and effective utilization.

The efficient use can only be made with comprehensive information on where they are located and how they are used, as well as the information of how these limited resources should be used in the immediate future according to well organized plans on a global scale.

5. Need of Global Information System

Today's policy-makers confront with acute inevitabilities of the explosive increase of world population and the depletion of limited resources on the earth.

When any families or corporations face with devastating situation like bankruptcy, good householders or managers try cooperatively, first to gather information on what they have left in their hands, and secondly to plan the effective use of their last resources, then thirdly to develop alternative means and sources which enable them to escape from the expecting doomsday.

In analogous to them, today's policy-makers should focus their attentions and efforts, first for the establishment of global information system on energy, food, natural resources and economic activities. Having their concrete information systems, policy-makers can direct properly and effectively the research and development of various alternative energies, which require huge amount of capital and human resources. Once the systems established, they can also be used for the administration of the effective usages of the developed alternative energies.

Such concrete global information systems need to be established by coordinations of experts in the various fields and countries, and are vital necessity with the following viewpoints;

(1) to assist policy-makers on the proper direction of the research and development investment of alternative energies,

(2) to make effective conservation of limited resources,

(3) to administer the developed new energies for their effective utilization.

Currently many international meetings on various global problems have been held in many parts of countries, stressing the international cooperation and coordination. Though the meetings certainly promote understandings among experts of various countries, they unfortunately tend to end as other diplomatic meetings without producing constructive, practical means and tools for constant cooperation to cope with the problems. Even in such cases when international research institutes have researchers sent from various countries, they are often out of their daily problem area in their countries, so that their cooperative study became aloof from and hardly implemented back to their own country's needs.

Many reports on energy policy analysis and evaluations are now also constantly appearing. As the world goes around, another round of reports will be created, causing policy-makers and practitioners to disagree in confusion, because of their full of verbal discussions, speculations and arguments. The analysis and evaluation need to be more quantitative with a sound basis of facts and figures.

Today's and future problems are globally interrelated one another. Solutions to them require interdisciplinary and international cooperation, for which close communication among experts of various fields and countries is mandatory necessity. It is therefore imperative to have a new way of communication lines for the close cooperation among the experts, while they are engaged with their daily, local problem at their preferred locations.

6. Global Cooperation for Quantitative, Predictive Approach to Global Problems with New Communication and Computer Technologies

As will be described later, the global information system with the dual use of computer conferencing system and of distributed computer simulation and data base management systems on global computer network, should be constructed by immediate, worldwide and coordinated efforts with interdisciplinary and international participations of experts. The information system will realize the creditable, quantitative and predictive analysis and well organized planning on the future energy situations in terms of national economies and in global perceptions, and may also contribute to the provision of practical means and tools for daily use by policy-makers and researchers.

Computer conferencing system on global computer network can provide a new communication media. Followings will then be recommended;

(1) Implementation of a computer conferencing system on a global computer network.

(2) Establishment of a management center for the computer conferencing system to be used by experts around the world in order to exchange their messages as well as technical, scientific, educational, environmental information.

Policy analysis of global problems requires long-range predictions. The analysis has to be scientific, which implies quantitative. As will be described later, the scientific, quantitative, long-range predictions of policy analysis of global problems can only be made creditably by distributed computer simulation system on global computer network, which system is to be constructed by experts of various disciplines and countries.

Predictive computer simulation eliminates to a considerable extent the ambiguities of discussions and arguments. It is especially so without such a study, being made in relation with socio-economic activities in various countries. For example, though most recent reports on energy issue present smooth curves of future trends of various energy supply and demand even up to the year 2000 or more, various economic indicators in the past, especially around the time of the last oil embargo, fluctuated severly. This shows that such smooth trends in most reports will not be true in the future, and that more reliable and creditable predictions of future energy usage are now necessary. This necessity is particularly warranted for most of the world's policy-makers and practitioners concerned themselves even with the small fluctuations of business behaviors.

The system analysis with judgements of knowledge and experiences in technology and economies required prior to the computer simulation of the energy policy will direct effectively the huge amount of capital and human resources necessary for the constructions of data bases, by the experts on the distributed global computer network. The data bases thereby increase credibility and accessibility for their usages by daily decision-makers in various parts of disciplines and countries.

Not only the submodels of distributed computer simulation system, but also data and information banks associated with the system can be used integratively as well as modularly for the daily use by the experts, providing total service of global information system. The distributed computer simulation system coupled with computer conferencing system can also be used in interactive mode for the solution of conflicting problems among nations, such as the tug of war on precious crude oil.

It is therefore recommended that scientific policy analysis of global problems should be made with globally distributed computer simulation system for betterment of international and interdisciplinary cooperations. It is then now necessary to establish a permanent operational means which will assist daily policy-makers. Those means are constantly updated data bases and quantitative computer simulation models, as well as communication media among experts throughout the world.

IV. NEW COMMUNICATION AND COMPUTER TECHNOLOGIES FOR GLOBAL POLICY-ANALYSIS

1. Global Public Computer Communication Network

1.1 U.S. Public VANs

Many computers usually quite dissimilar are now located throughout America. Currently they are being connected by telecommunication lines to form networks operating with packet-switching, and these so-called value added networks (VANs) have been in operation for the past few years in the United States. The most typical one is the ARPANET of the Advanced Research Project Agency (40). Its several commercial versions, such as TELENET and TYMNET, have started their services in the United States several years ago (7, 21, 44, 71, 77). (See Figure 1 for TELENET Logical Map.)

Packet-switching, new data transmission technique, is a computer-based technology involving a network of mini-computers which are interconnected by high-speed transmission facilities and which have been programmed to perform sophisticated switching, interfacing, and error control functions. Data entered the network through one of these mini-computers is subdivided into "packets", each of which contains the destination address and error control information. Each packet is individually routed through the network over the optimum (least delay) path existing at that moment; the packets are reassembled into their original order at the destination mini-computer and are delivered to the addressee of terminal or computer. The data transmission through the network is essentially instantaneous. 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.

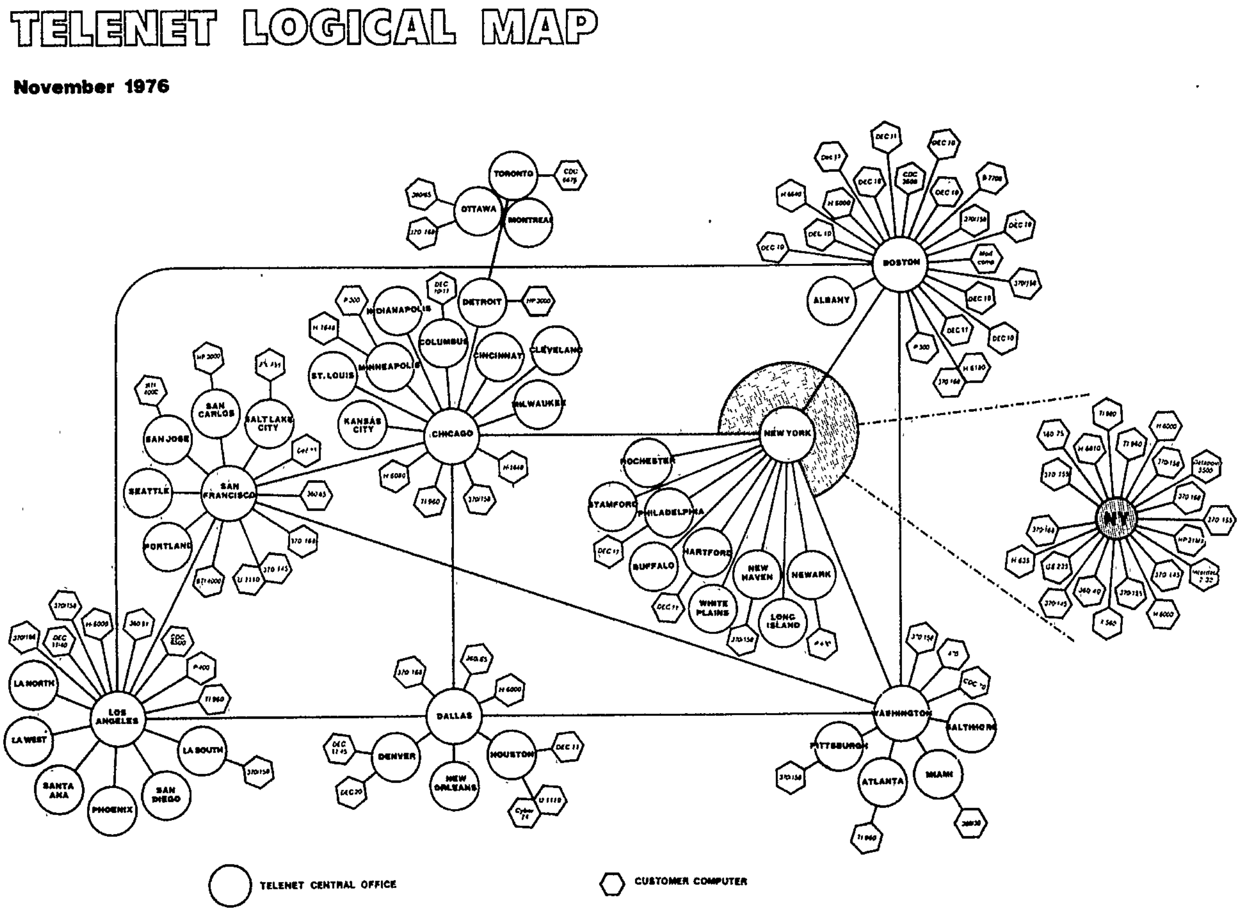

Fig. 1

Up to the present time, however, the computer user is deterred from engaging in overseas data communications by a number of constraints, chief among which reasons are the low quality and high cost of existing international data communication services. The availability of public packet-switching computer network for international communications will substantially remove both of these constraints.

1.2 Global Public VANs

The U.S. public VANs enable efficient and convenient data communications among terminals and computers and have now been extended to more than 25 major overseas countries and regions to form global public VANs. (See Figure 2 for the access to host computers of the U.S. VANs from overseas countries.) Those countries and regions are:

Operational (September, 1980):

Alaska	Italy
Argentina	Japan (DDX-PS)
Australia	Luxembourg
Austria	Mexico
Bahrein	The Netherlands
Belgium	New Zealand
Bermuda	Norway
Canada (DATAPAC)	The Philippines
Denmark	Portugal
Finland	Puerto Rico
France (TRANSPAC)	Singapore

West Germany (DATEX-P)	Spain
Hawaii	Sweden (X.25 domestic VAN)
Hong Kong	Switzerland
Israel	Taiwan
	The United Kingdom (PSS)

The U.S. public VANs have also been interfaced with the international telex network of ITT Worldcom so that any host computers of the U.S public VANs can also be utilized from almost all countries in the world without setting up a permanent account with the communication administration in each country.

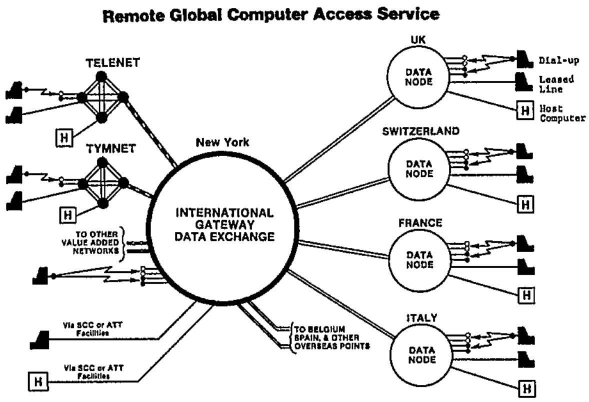

Fig. 2

The VANs will allow a standard interface protocol for interconnection of host computers, which protocol will also form a basis for the interconnection of various national public VANs across boundaries as creating truly global public VANs, thereby enabling utilization of a computer in a country from any other countries. Some of these countries are now vigorously organizing and interfacing together their national public VANs, such as DATAPAC in Canada, PSS in the United Kingdom, TRANSPAC in France, DATEX-P in West Germany, EURONET in Europe, DDX-PS (domestic) and VENUS (overseas) in Japan, etc. (12, 73). Their national public VANs have already been connected with the U.S. public VANs except Japanese DDX-PS.

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, will be inaugurated in September, 1980. VENUS, which will be independent from ICAS but interfaced with the U.S. VANs, will also be interfaced with DDX-PS sometime in 1981, enabling computer (in Japan)-to-computer (in the U.S.) conversation.

1.3 Benefits of Global Public VANs

Much of the potential resources sharing that a packet-switching network would permit is international in scope. Most of the services that will be offered over the network will be highly specialized -- such as special computer programs for spectral analysis needed to cope with pollution environmental problems or access to a large-scale econometric data-base needed to forecast national economies.

Current experience with existing packet-switching networks strongly supports the arguments for collaborative work among geographically dispersed research workers. An international packet-switching network could substantially strengthen multi-national educational and research projects engaged in by widespread institution.

With the establishment of such a global network, not only data communication among computers but also programs, data bases and information on educational, medical, agricultural, environmental, scientific and engineering fields can be exchanged nationally within individual country and internationally among participating countries, thereby establishing the "Global Information Network", which promotes cultural diffusion and understandings among countries.

2. Distributed Processing

2.1 Introduction

Advances in the various technologies of mini-computers and communications made pursuit of the 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 the centralization (3). Three basic functions necessary to configure information networks are the following.

2.2 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 public VAN, the distribution of network processing was made possible and consequently the network processing was separated from the functions of information and database 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 electricity.

2.3 Distributed Information Processing

--- Manipulation of information to produce the desired result, 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 on-line databases capable of supporting heavy access loads produced soon 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 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 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 in their relative infance. A great deal of work and time is necessary before these protocols will be available to end users. The network processing function has been presented as a utility to the information and database processing functions. As such, its role in the restart/recovery logic of distributed information and database processings remains largely unexplored.

The distributed computer simulation system is the application of this distributed information processing capability to application programs, particularly of simulation activities.

2.4 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 of database integrity, 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.

2.5 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) -- as opposed to the more traditional approach of fitting the problem to a predetermined solution. The process is enhanced by the newfound ability to define a network -- any network -- as a set of inter-related 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 processings may well be accomplished with virtual network file system which will be described below.

3. Virtual Network File System

3.1 Introduction

The hosts 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 the details of the operating systems, file systems, and the command languages on each host he wishes to access.

Interface of programs and databases written in other languages and resided in geographically dispersed, dissimilar computers has been proposed to be made with Network Interface Language (NIL), and distributed (or virtual) operating system (8, 77). Another approach, which is more general in nature with possible application to GLOSAS Project, is now being developed under the auspices of Institute for Computer Sciences and Technology (ICST) of the U.S. National Bureau of Standards (NBS) (32).

3.2 CCL and CCLP on Virtual Network File System

A Common Command Language (CCL) and a Common Command Language Protocol (CCLP) of this approach 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 common command language protocol (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.

The CCL and CCLP will provide the user with a simple, consistent view of files and file systems throughout a heterogeneous computer network. The CCL will create the user interface to a virtual network file management system by providing network-wide file commands. The virtual network file system describes a file system which is system independent. Each system in the network can interwork with other different systems in mutually understood terms. The virtual network file system provides a screening of the details of local operating systems from the network environment.

3.3 Virtual Network File System

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. The virtual network file system is composed of a set of objects connected by links. The objects and links describe a tree structure of nodes with directed arcs as shown in Figure 3. The virtual network file system has a unique named root node that is initially accessed when addressing the virtual network file system. The root object has attributes associated with it that describe the entire file system.

There are two types of objects in the virtual network file system. Any object that has an arc leading from it to another object is a directory. Each directory contains no stored information except the attributes about the objects which are linked to the directory by arcs. Objects that have no arcs leading from them are files. A file contains stored information along with attributes which describe the information. Information in a file is structured into zero or more records. All objects in the virtual network file system are described by attributes. Attributes are the properties or characteristics of the object and the properties of any objects linked to the object.

3.4 Summary

The application of these CCL and CCLP with a virtual network file system to distributed computer simulation would be to make each file management system in dissimilar computer operated cooperatively together as well as each system working with its associated submodel resided in the individual computer.

4. Computer Conferencing System

4.1 Introduction

Computer is now beginning to be used in a similar way for communication among human beings. This communications form on a computer network, computer conferencing system, 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 (31, 34, 35, 52, 53).

Computer conferencing system can be broadly defined as the integral use of computers to structure and facilitate communication among a group of people. The system is based on written entries and read-out (rather than by speaking and listening) made through a computer terminal connected to a host computer through any ordinary telephone. When the message and any editing are completed, it

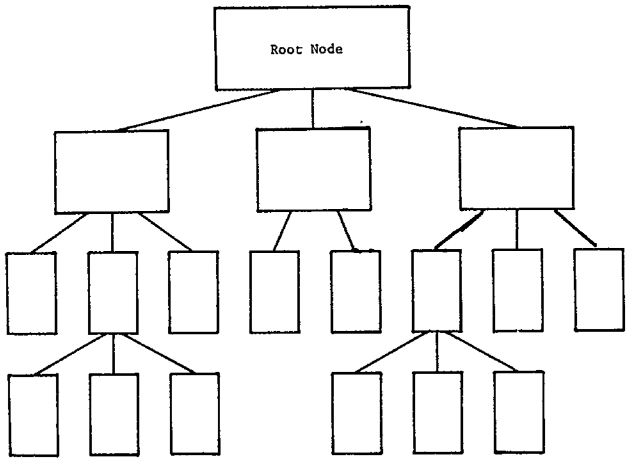

Fig. 3

Tree Structure of Nodes
of
Virtual Network File System

is sent over the telephone to the host computer. The computer assigns a number and date and time to each entry and then stores it for delivery to each of the recipients the next time each one accesses the system, i.e., the entry may be obtained on the recipient's terminal immediately or at any time in the future until it is purged from the computer's memory. Thus, the sending and the receiving of material may be separated in time and space (54).

Namely, the participants may be geographically dispersed, with their various locations limited only by the availability of adequate telephone lines. Also, the host computer mediates the communication. Thus, the participation may also be dispersed in time. The computer conferencing system thus is designed to use the storage, retrieval, and processing capabilities of the computer to facilitate the transfer of large amounts of communications among geographically dispersed group members at their desired time and space of sending and receiving their messages.

4.2 Features

Some of the capabilities provided to the participant in this remote, written communication form are the following:

(1) One can send a "public" message to everyone in the conference, or a "private" message to designated respondents. In addition, the message can be signed or anonymous.

(2) Time and distance barriers are removed. Persons can send and receive communications whenever it is convenient for them and whenever they can plug in a portable terminal and connect it to a telephone. On the other hand, geograpically dispersed persons can communicate in "real time" or synchronously if they are all at terminals simultaneously.

(3) A permanent, written copy of the communication is produced, with each participant receiving all "new" communications whenever they sign on or finish making an entry. Previous communications can be retrieved at any time by asking for a particular author, date, a key word, etc., or by asking for all entries between certain numbers or dates.

(4) Editing routines make corrections and line up the entry to make it appear neat. (No secretary needs to be interposed in the communications process in order to produce presentable written communications).

(5) Questionnaires or "votes" may be administered through the computerized system, with the results tabulated and fed back immediately to participants as anonymous totals.

4.3 Distinctions

Computer conferencing as a social process differs markedly from other modes of communication, such as face-to-face meetings, telephone, or letter-writing. Among the ways in which the norms and nature of communication are altered are the following (22):

(1) Everyone can "talk" or input whenever they wish, rather than having to "take turns" as in face-to-face verbal communications. Rather than only one person "having the floor", all participants could be typing in messages simultaneously. No one can be interrupted or "shouted down".

(2) Computer conferencing is much less "intimate" and self-exposing than verbal modes. Only word (which can be carefully considered and edited) are transmitted, not appearance, or other personal characteristics. The possibility of sending anonymous messages "legitimately" to other members of the conferencing group increases the possibility for "impersonal" relatively emotion-free communications. Another aspect of this impersonality is that the communicator is alone, rather than in the company of others.

(3) Since all communications are written, computer conferencing is less "rich" than face-to-face or telephone, in that participants have no eye contact with each other, facial expressions, gestures, verbal intonations or pause, etc.

(4) There is no danger of "forgetting" or "losing" communications. The complete transcript of entries is available at any time.

(5) Computer conferencing may loose some richness available from other modes of communications, but it also gains the escape from the uncomfortable embarrassment of having to face or listen to a potentially resentful or negative communication. The various forms of anonymity of computer conferencing have definite implications for willingness to express deviant or unpleasant opinions.

4.4 Application to Modeling

With the development of computer-based group communication media, the computer may play an increasing role in managing the complexities of the modeling process. Large-scale policy models are usually developed by groups of several people. Frequently, some of these model builders work in different locations around the country or the world; they nearly always come from different disciplinary backgrounds. The users of their models typically come from different organizations, with their own perspective on problem solving. These basic characteristics of the modeling environment create a number of communication problems. These include communication barriers between model builders and users; obstacles to communication among model builders; inadequate documentation; and problems of validation. To address some of these problems, there should be more frequent communication in the modeling group, easier record-keeping, special formats for presentation of results, structured interaction, and user training procedures (26).

Computer conferencing system can link together modelers and transcend the seemingly artificial geographic and academic boundaries which heretofore have prevented the pooling of their efforts. Computer conferencing system, then, represents the availability of adequate communication links amongst modelers (64). It is an essential feature of our efforts to inject (in a "valid" and "useful" manner) the essence of gestalt in simulation models, since the unified configuration has properties that cannot be derived from its parts.

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 executive 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 (54).

On the other hand, a model and its data are not separable. Much of the data required for simulation is "soft" data which exists in the minds of "experts" in the form of projections, probabilities, estimates, confidence limits, etc.. A proscriptive method for obtaining this "soft" data base is the delphi procedure, which utilizes a structured group communication process to "extract" results. Delphi can be assisted with computer conferencing system with tremendous savings in terms of cost and time. Thus, computer conferencing system may also be effectively integrated into the database development process.

4.5 Application to Large-Scale Modeling

To comprehend the gestalt of a simulant during modeling, a model must relate all of the component parts, rather than looking at each part separately, especially for the case of world modeling which has appeared in recent years (17, 30). Any world model should not only seek the expertise in different parts of the "world" but also the expertise in the different disciplines needed to adequately understand the structure of the world system.

When models have become more sophisticated, validity and credibility of the simulation results are becoming important issues. This is because the need for one-modeler efforts will tend to diminish in the future. Moreover, the inter-disciplinary team may not all be physically present at the same location, but, more likely, would be spread out geographically. It is then evident that model builders should be talking to each other while the models are being developed, as well as after the model has been completed.

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 (25).

As we perfect our growing network of computer communication systems, relevant data will be available as inputs to sophisticated simulation models whose outputs will aid in the search for viable alternatives and optimal solutions to many man-made problems, some of which may affect indirectly all of mankind. Efforts to build models for testing of "global" decision, as in the "Club of Rome", 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 (19).

4.6 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 (15).

Almost inevitably, one is led to a considerable degree of specialization, sometimes along the lines of professional skills (data analysis, formulation, computation, interpretation, debugging, etc.), or else, more commonly, along the lines of problem technologies (refining, logistics, economics, final demand, etc.). 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. The entire team has to work under some sort of discipline ('organization') governing the interactions of the sub-teams.

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 by cost and convenience factors. The use of current technology, such as the minicomputer and global public VANs, enables a user to communicate messages and other written materials to persons all over the United States as well as the world.

During development of simulation sub-models in each region by experts located therein and subsequent integration of those complementary sub-models, there is a need for close collaboration among them through immediate communication lines. Also, during execution of interactive gaming simulation, pseudo-decision-makers require immediate communication to allow the generation of a policy consensus (74).

The computer conferencing system can also be used for joint preparations of unique, creative and integrated proposals, reports, policy recommendations and papers by geographically distributed experts in various disciplines and countries with the simultaneous use of quantitative computer simulation on a global computer network. Those reports and policy recommendations can then be distributed immediately to the participants by and throughout the same system. Rapid and worldwide dissemination of such information will accelerate collaboration among experts in various countries in policy analysis and evaluations, as meeting today's need to solve closely interdependent relationships and problems (25).

The computer conferencing systems also accelerates the project progress, and reduces at the same time the necessary numbers 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 (23). 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 academe and research fields in global scale. Computer conferencing system as a new communication medium thus offers many opportunities for the innovative application of a new technology in the interests of democratizing and humanizing society.

5. Computer Simulation

5.1 Introduction

The term simulation is generally used to cover modeling, simulation and gaming. Current usage, however, suggests that more properly, 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 mean 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 (29).

All simulations can also be placed on a continuous ranging of the following three categories;

(1) man-machine which utilizes human to model the simulant, i.e., the real-world or hypothesized system that has been modeled and to act as decision-maker.

(2) machine-simulation in which the structure and activity as well as decision-making functions are entirely imbedded 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 human and computer.

Gaming simulation here in this paper implies to man-machine simulation.

5.2 Computer Simulation for Management Science

Historically, computer has been used for collection, retrieval, and storing of statistical data and then making mathematical calculations therewith. The computer is now, however, being used increasingly to assist decision-making by individuals, enterprises, and local and national governments.

"Management" is the governing system which involves human in their achievement of desired goals. It is a technique, but not a goal. Many techniques have been developed and refined from art to scientific discipline (5). Management science, as it implies, is the scientific approach to the analysis of management of enterprises or systems and their behavior whether individual, communal, national or international.

Those systems cannot easily be altered after once being established, as the most extreme cases there is the disruption of some political system by "revolution" or "coup d'etat". The behavior of such systems cannot repeat exactly at a later time historically. A scientific approach, however, tries to disaggregate a whole system into components for their isolated examination. A truly creative scientists then may reconfigurate and synthesize a new system from the components with his new vision or goal.

Corollaries to such a program will allow improvements. Thus the various phypothesis, methods of approach and goals may be examined to verify, as to (1) separation and isolation of components, (2) reproduction of system behavior, (3) alteration of system, etc.. In contrast to physical and nonliving system, these corollaries applied to social and living systems are hardly possible. Consequently, "management science" has an inherent contradiction between the "management" and its "scientific" approach.

The remedy to this is to create a model which enacts the system behavior, much as is done by an airplane model in a windtunnel. Computer simulation, which utilizes a software instead of a hardware model, is therefore the essential and vital tool of management science. Computer simulation for decision-making requires systems analysis and mathematical modeling of the assigned problem, which model is to be executed repetitively in order to study cause-and-effects of various parameters of decision-makings prior to their applications in practical use.

5.3 Methodologies of Computer Simulation

5.3.1 Dynamic Methodologies

Fundamentally, there are two kinds of methodologies to forecast the future of socio-economic behavior; one is econometrics and the other is systems dynamics.

(a) Econometrics

For sectors of unknown structure, it simulates the future dynamically based on empirical and statistical treatments of available data.

Econometrics is the statistical extrapolation of past data, and is mostly utilized for the predictions of short (0 to 5 years) and medium (5 to 10 years) ranges. Lack of long range forecasting capability is the major drawback of econometrics for the analysis of energy policies which often require large investment, long duration and subsequently large influences on socio-economic behavior. Interactive gaming simulation cannot also be applied with econometric model. Therefore, the test of "what if" assumptions of various policy alternatives cannot be performed interactively and successively in gaming mode. Consequently, this GLOSAS Project excludes the econometric model, unless otherwise necessary for the forecasting of socio-economic sectors whose structural mechanism cannot be revealed clearly.

(b) Systems Dynamics

Systems dynamics analyzes structures of social system, as simulating and predicting the system behavior dynamically.

Systems dynamics is an engineering approach with reasoning (or theory) and educated guessing of the structure and mechanism of long range socio-energy-economic behavior. Systems dynamics models are customarily written with continous systems simulation languages, such as DYNAMO, CSSL, ACSL and CSMP. In contrast to the aforementioned drawbacks of econometrics, systems dynamics simulation is especially suited for the test of "what if" assumptions of various policy alternatives of major energy projects with long time duration.

Systems dynamics can also incorporate, by proper manipulation of the programming language, with econometrics as well as other static methodologies, such as input/output, linear programming and cross-impact method (56). (Japanese researchers once made a study to convert Japanese econometric model to systems dynamics model, and found the reverse conversion impossible.)

In a philosophical sense, econometric approach may be Lockean (i.e., data oriented) and systems dynamics may be Leibnizian (i.e., structurally oriented). However, this GLOSAS Project will take Kantian approach (i.e., data and models are inseparable) (41).

5.3.2 Static Methodologies

GLOSAS Project also intends to create new solution methodologies as integrating the following statical ones used conventionally and individually, with the usages of the distributed computer simulation system and the computer capabilities;

(a) Input/Output Method

Sampling data of the real world or of simulation at any time, it checks the balances of input and output of social systems statically, and subsequently verifies the simulation model.

(b) Linear Programming

Sampling data of the real world or of simulation at any time, it performs decision-making statically and automatically, in order to satisfy an objective of some particular sector of the social system.

5.3.3 Communication-Oriented Methodologies

GLOSAS Project with multi-national, interdisciplinary experts dispersed geographically intends to utilize following communication-oriented methodologies with the use of global computer network;

(a) Policy Delphi

The policy delphi (41) is a structured communication process geared toward generating opposing views on the potential resolutions of a major policy issue. It is not a decision-making tool, but rather an aid to the process, in the sense that its objective is to generate opinions and supporting evidence. The policy delphi can thus play an important role in the overall development of large modeling efforts by generating both information and involvement.

(b) Cross-Impact Matrix Analysis (45)

This analytical method utilizes interactive influences of various decision-making processes with a group of experts to assess and evaluate 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. (See Figure 4)

The cross-impact technique provides the model builder with not only the sought-after involvement of policy makers and others with "expert" judgement, but it can simultaneously provide the database and even the structure for a model.

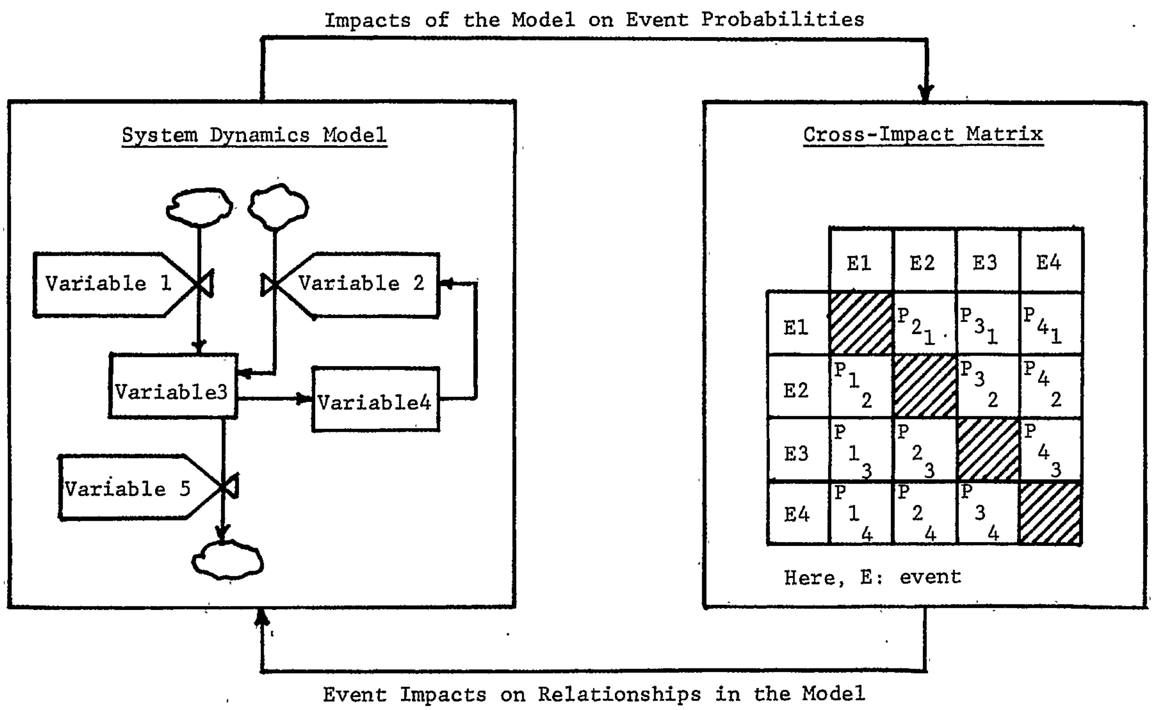

Fig. 4

Interrelationship
between
System Dynamics Model and Cross-Impact Matrix

5.4 Summary

Computer simulation is now forging ahead of computer science, and moreover, has a new dimension with emerging computer network technologies as will be described below.

6. Distributed Computer Simulation System

6.1 Introduction

Advent of distributed computer network was accomplished by the creation of vertual terminal concept which enables almost absolutely error-free hand-shaking procedure for data transmission between network nodes. This network made possible to share resources of particular software, data bank, computing power, etc., even from remote terminals. This sharing resources has become to be widely used with another advent of the value added network (VAN) concept by the establishment of public packet-switching network. Namely, as sharing high cost of data transmission lines, a number of remote terminal users can now access with particular resources of their choices.

Trends so far experienced with private packet-switching network, such as ARPANET, or with public packet-switching network, such as TELENET or TYMNET, have however been to provide aforementioned computer oriented information resources individually to remote users. In contrast to such individual usages of resources, the distributed computer simulation system enables collective and integrative use of models, which are written by various continuous system simulation languages and resided in various dissimilar computers around the network. Ultimately, such a collective and integrative approach will include data bases and various programming languages. It is therefore suggested here that a comprehensive study with integrated models should be made with the use of distributed computer network as splitting various models to dissimilar computers around the network.

6.2 Complementarity of Global Socio-Energy-Economic Simulation Models

The systems for obtaining, distributing and using energy play a vitally significant and inseparable role in the functioning of the nation's economy, so that energy policy cannot, nor should it be, separated from general economic policy. The characteristic conditions of different energy models are not substitutable, but rather are potentially complementary to one another in whole or in part. This condition distinguishes energy models from those known as macro-economic forecasting models, which have evolved until there now are a number of individual models that are being used in attempt to solve the same forecasting problems.

Smith and Sparrow (43) emphasized the following two aspects of energy simulation modeling:

(1) Complementary characteristics of resultant energy models, and

(2) Modular process of modeling and integrating energy models.

By its definition, the complementary energy models need to be interfaced each other to obtain total, comprehensive results. When global socio-energy-economic system is considered, the macro-economic forecasting models of various countries also become complementary to one another, and need to be interfaced together.

6.3 Large-Scale Simulation Modeling

Various energy models have been constructed utilizing highly developed reasoning using 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 energy problems; and the model users must demand 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.

Consequently, the interconnection of various complementary energy models, which may be written with various simulation languages, will become vital necessity.

6.4 High Credibility with International Cooperation of Experts

Up to present, computer simulation has been performed in batch mode, recently in time-sharing mode, both on a single computer. Many computer simulation studies of a world energy system are also conducted by interdisciplinary scholars of a single university or of one country. While they construct simulation models of economic activities of a country other than the United States, they pretend knowing them well. This is illogical, however, since they, say American scholars, would not know about the economic activities of another country, e.g., Japan, better than Japanese scholars. Consequently, the details of each sector (or country) model is necessary to be known only to the expert who will construct the model, but not necessary to every user of the systems. This is an analogy to the fact that American would not need to know every detail of Japanese economic systems for his daily life in the U.S..

On the other hand, computer simulation of socio-economic-political systems has been progressing rapidly in social dynamics and econometrics for business, local, national and international affairs. As the boundaries of their simulation expand making them more realistic, it is increasingly evident that the simulation models require computer communication links for the sake of resource sharing of computer hardware, databases, simulation software and especially of research resources of interdisciplinary brainware. These requirements are due also to the fact that the socio-economic modeling, either with social dynamics or econometrics approach, requires enormous effort even for a single nation, and yet, the model builder knows well the need for interaction with other nations in natural resource allocation, environmental control, foreign trade, and monetary policies.

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, 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 remedies to these problems, as constructing on the VAN the globally distributed socio-energy-economic simulation system. The system will enable to interface and 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.

6.5 Need for Distributed Energy Database Management System

In recent years integrated databases have become increasingly more prevalent in the operations of business 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 straightforward 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.

Indeed, many applications which such users desire come in the form of existing computing and modeling systems which are, themselves, self-contained. A great deal of time and effort may have been expended in learning to use and develop applications and models under such a system. The typical user would not want to abandon this investment, but would be satisfied with a system which would allow him to interact simply with a database. If this investment were coupled with the investments of other users in other systems, the cost of forcing users of this type into the fixed regimen of existing database systems would be enormous. Another problem which arises is that the various models and modeling packages may run under different operating systems which could present the potential for prohibitive conversion costs.

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 (14).

During the developments of submodels corresponding sectors or regions, experts construct their own databases by their preferred computers and languages, or utilize existing ones which are available via computer networks. The GLOSAS Project will utilize those databases during the execution of total interactive simulation models, as well as providing the databases modularly and individually for the use by highly skilled, non-data processing professionals as a tool for performing their daily work.

The virtual network file system mentioned before may accomplish the separation of functions between information and database processing and also the realization of distributed information and database processings.

6.6 Bottom-to-Up vs. Top-to-Down Approach

Energy system is also a complex and global problem with interwoven relationships of foreign trade with other countries. Subsequently, 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 (4). 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, this 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 industries.

6.7 Cost Saving

By this top-to-down approach, it will be attempted also to utilize to the maximum bits and pieces of existing complementary models, which are kept as much intact as possible, and wherever they can be fitted into the whole in order to minimize unnecessary expenditures of time and effort on new grass-root, analysis and modeling of component systems. The distributed computer simulation system will then bring a significant cost saving without becoming entangled in expensive re-construction of substitutable and/or complementary component models from scratch.

There has been no attempt made yet on the development of an interfacing software which enables the distributed computer simulation. Consequently, no one has ever combined various socio-energy-economic models distributively and interactively. Multi-national distributive, interactive "peace" gaming simulation will be possible only after the development of the virtual network file systems mentioned before, and will be conducted in the future.

6.8 Trans-national Data Flow Regulation

Never before has information been regarded as such an important commodity, indeed a national resource. Information is power, and economic information is economic power. Information has an economic value, and the ability to store and process certain types of data may well give one country political and technological advantage over other countries. The proliferation of global public VAN, in turn, may lead to a loss of national sovereignty through supra-national data flows. Any barrier to open and free flow of information among nations will, however, impair understanding among the people of the world, thereby increasing threats to the world peace.

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 (28). Many nations are expected to have national data-protection laws (1), 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.

6.9 Summary

No integrated and comprehensive study of the energy effects to various socio-economic activities, even within a single country but particularly across national borders to include several countries on a global scale, has yet been made by predictive computer simulation. This is because;

(a) any individual computer simulation study tends to be biased within a single discipline, subject or methodology;

(b) any individual study itself tends to grow into a large and complex simulation model, which will overload even a large computer memory;

(c) consequently, the combination and interfacing of several such models become an impossible task with any present-day single computer.

Integration of the complementary energy models requires;

(1) to cope with the above problem (a),

--- by extensive use of existing computer conferencing system for good interdisciplinary coordination of modelers;

(2) to cope with the above problems (b) and (c),

--- by distributed computer simulation system on a global public VAN for interface of those models to be kept as much intact as possible.

The distributed computer processing system will relocate various data processing functions to where the work can be done most effectively and responsibly, and then combine the distributed functions into a cohesive system via data communications. The relatively low costs and the increased capabilities of minicomputers, combined with the availability of a similar number of cost-effective data communications options, make the distributed processing systems concept extremely intriguing, both as a system enhancement and as the bases for an initial system.

The newly establishing global public VANs will make it possible for geographically dispersed dissimilar computers to perform distributed data processing (DDP). The DDP applied for simulation is the distributed computer simulation systems (DCSS).

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

The distributed computer simulation system will enable to interface various component models written in different simulation languages, which models will be resided in the geographically distributed dissimilar computers. These component models will then be executed as parts of the total simulation required, interactively, cooperatively and simultaneously in computer-to-computer conversational mode via a global public VAN. A comprehensive study with integration of complementary component models can be made to produce more reliable and comprehensive computer simulation study than ever before. The distributed computer simulation system will then open a new era and dimension of the socio-energy-economic simulation study in international scale.

References (50, 51) describe the existing distributed simulation system for air traffic control and gaming simulation. This technique should be acquired, enhanced and applied to this GLOSAS Project. Another reference (78) also emphasized the need of distributed computer simulation system for global energy policy analysis.

7. Distributed Gaming Simulation

7.1 Introduction

Interactive gaming simulation, which is especially suited for the solution of conflicting social problems, provides a better intuitive understanding of a given problem situation and to lead through successive approximation to the construction of a realistic analytical model (20). 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 lead to a better intuitive understanding of the problem structure and thereby to help the analysist in the development of models that gradually become more and more appropriate for dealing with the real-world problem situation. Thus the gaming simulation is pre-analytic in nature. An essential part of the routine of playing the gaming simulation is a constructive debriefing or review session in which the participants are asked to engage in;

(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?

As a result of such inquiries, the gaming simulation is almost invariably changed in some respect between plays. The gaming activity, therefore, should not be viewed as a series of trial runs of a particular simulation model but as a dynamic process in which a more and more realistic conception of the world gradually evolves. A gaming simulation, therefore, must have the built-in capability of such potential self-correction.

Because of primary function of the gaming simulation, emphasis may not need to be placed on obtaining the most precise and up-to-date statistics to serve as input data for each component model, but rather, it is necessary to include in the models as many important factors descriptive of global economic interactions as are compatible with the requirement of keeping the gaming simulation simple enough to be playable. The absence of precision in the initial choice of numerical inputs can easily be remedied later by substituting more precise data when these become available.

The move structure of each gaming cycle, called "scene", is shown in Figure 5. There is one important feature of the gaming simulation which deserves to be pointed out first. As it is evident from the indications given in the figure, the model contains certain stochastic elements. Some of these reflect influences entirely exogenous to the model, such as those controlling the weather and the growth of population. Others, such as technological breakthrough or the amount of labor unrest, are endogenous in the sense that, while they are the result of random (i.e., Monte Carlo) decisions, their probabilities of occurence can be affected by player actions. The effect of the presence of these stachastic features is that the players have to plan in the face of some uncertainty as to the results of their decisions. Some of the uncertain occurences may be supplied from the cross-impact matrix mentioned before, if applied.

In this respect the model differs markedly and, it is hoped, in the direction of realism from standard econometric models in which economic output is determined solely by input allocations. Consequently;

(1) Each component model is better to be constructed by expert of the model subject, if possible;

(2) Those models are better to be constructed by systems dynamics, instead of econometrics methodology, because the systems dynamics is particularly suited for intuitive analysis of system structure, its dynamic behavior and also for the ease of revising model structures;

(3) Due to the nature of policy analysis of socio-energy-economic behavior, various continuous system simulation languages to be used for the systems dynamics modeling must have the capability to interact with model during its execution in order to insert the policy-decision parameter values at any time interval;

(4) It would be convenient and/or necessary to interface the component, systems dynamics models with cross-impact probabilistic matrices.

7.2 Computer Conferencing System for Gaming Simulation (41)

Many previous gaming simulations often neglected the important feature of communication processes among game-players that fundamental to the play of the gaming simulation. The rational for the recent rapid growth and attractiveness of gaming simulation becomes evident when we examine the simulants, which the gaming simulation seeks to mimic. This is because the problems of today are more complex, involving systems and interacting subsystems that go beyond normal human ken and which do not yield to conventional jargon or traditional forms of communication. In essence, the nature of today's and future society present challenges not only in determining solutions for these problems, but more crucially, the actual description and comprehension of the problem is becoming exceedingly difficult when one relies solely on ordinary communication methodologies, in order to comprehend the "whole" before the component of the "whole" may be investigated.

Gaming simulation is a spontaneous solution to the problem of developing a gestalt communication form and is a new future-oriented language. Gaming simulation is an "integrated", the most sophisticated communication mode, if coupled with computer conferencing system and distributed computer simulation system, which conveys more specialized complex messages than any other modes available today for the following reasons:

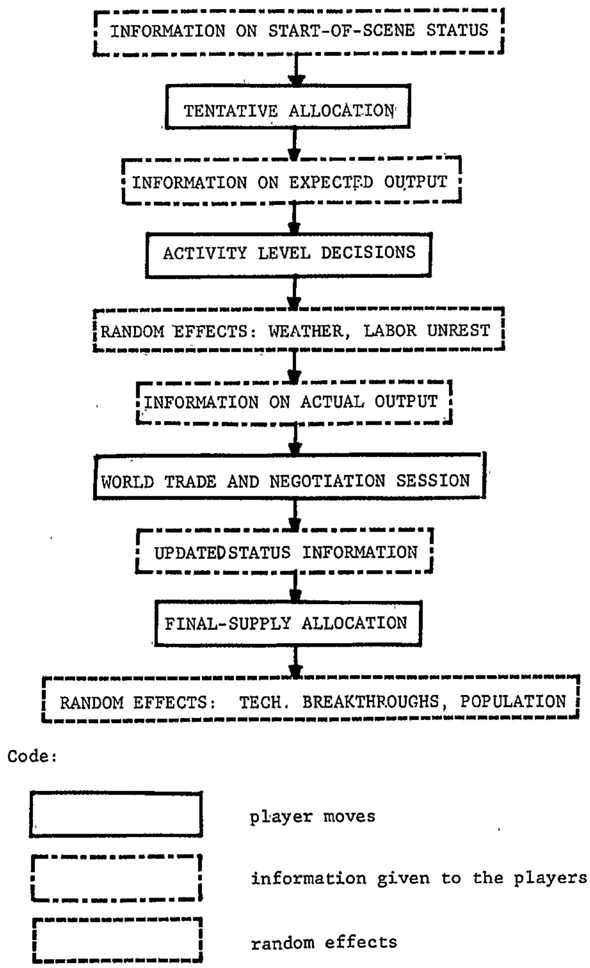

Fig. 5

Move Structure of Each Scene (20)

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

(b) The interaction pattern among the game players is not simple one-way or two-way communication, nor sequential dialogue between a central speaker and audience, but rather it is an uncommon, but very productive multilogue interaction which is essential to gaming simulation's ability to convey gestalt.

(c) Gaming simulation employs combinations of interactive communication and man-machine simulation technologies.

Once gaming simulation models are developed, they should not remain static entities, but open for continued discussion, evaluation and change. They should also be receptive to an interactive feedback derived from the actual play of the gaming simulation.

Gaming simulation, therefore, requires a specialized group communication process for comprehending the gestalt of a real world system or a simulant. Any technological advance which enhances the ability of a group to communicate should most favorably impact the gestalt formation. The primary interaction pattern in gaming simulation is multilogue, which is essential to the gaming ability to display gestalt of simulant. Computer conferencing system is a communications facility which enables a group of individuals who are separated in time and/or space to communicate with each other by means of shared files in a time-sharing host computer from a terminal. Any gaming simulation consisting of a high degree of multiple, simultaneous dialogue could appreciably enhance numerous features of the play of the gaming simulation by imbedding the multilogue in a computer conferencing environment. Those feature are:

(a) Game players may be geographically separated, and would not be feasible to congregate at a common location. Computer conferencing system will allow both synchronous and asynchronous remote communication.

(b) The time requirements for a large-scale gaming simulation, along with their time limitations and geographical differences, require asynchronous communication.

(c) Proper planning with the use of computer conferencing system will eliminate unacceptable noise level of multiple dialogues among game players.

(d) Private message capability of computer conferencing system will aid the selection of groups of individuals to engage in clandestine communications, a requisite structure in the modeling of numerous simulant.

(e) Computer conferencing system coupled with a sophisticated retrieval capability automatically preserves the history of multilogue taken place during the play of gaming simulation, not only to aid game players but also researchers interested in the posterior analysis of the gaming simulation.

(f) Designers of gaming simulation, operating in an interactive mode via computer conferencing system, could effectively apply various Monte Carlo or stochastic methodologies, such as delphi, cross-impact analysis and multi-dimensional scaling, etc., to obtain the desired conceptual map, which the designers have of the complex reality of the simulant. The conceptual map is needed to truly determine why certain outcomes occurred. This is an integral part of the "post-mortem" phase of gaming simulation.

(g) The development of excellence in gaming simulation area is an evolutionary process which requires a communication structure to be established not only among players but also between players and designers, throughout every phase of the gaming simulation.

The "marriage" of computer conferencing system and interactive gaming simulation benefits gestalt communication process not only as a logistic breakthrough to model human interaction systems, but as a research tool to gain theoretical insight into the sociological processes that take place in the human interaction systems.

7.3 Required Capabilities of Interactive Gaming Simulation

Major design characteristics of large scale interactive gaming simulations may be categorized as follows (74):

7.3.1 Use of Higher-Level Simulation Languages

Many discrete and continuous simulation languages have been appeared in the last two decades, to eliminate many of the difficult and tedious programming tasks common to all simulations and to allow the designer of a computer simulation to concentrate on the substance of the model. However, no similar higher-level programming language has been developed to implement large scale gaming simulation models.

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. For those parts to be simulated by computer, available high level continuous and/or discrete simulation languages and their combination should be used so that updating of the status of the simulated system, list processing, collection of statistics on the simulated system, and the generation of random variates, etc., would be performed with ease by non-data processing professional participants.

7.3.2 High Fidelity of Simulation

Since the primary objective of most gaming simulations is to provide a simulated experience with a large and complex segment of reality, a high level of detail must be reproduced to support the realism of the game.

As mentioned before, distributed computer simulation system on global public VAN will achieve this high fidelity with collaborations of international and interdisciplinary experts.

7.3.3 Flexible Structure between Computer Simulation and Decision-Making Mechanism

Highly detailed, multidisciplinary, many participant, long duration gaming simulations require the ability to store and manipulate a large amount of textual material to support a realistic and convenient flow of information between the computer simulation and the game participants. The preparation and maintenance of this material is one of the major tasks in the construction of a large scale gaming simulation.

It would also be desirable to provide for a mix of rigid and free form gaming by providing participants with capabilities for over-riding some of the decision-making mechanism in computer portion of the gaming simulation in order to respond to unanticipated decisions on the part of the participants. This flexible structure should also be incorporated with the modular complementary submodels of various sectors (or country) of global gaming simulation.

Since gaming simulation requires a large and varying number of participants to simultaneously interact in a common game, a very substantial problem of coordination between the activities of the participants and the simulation model as a whole arises. If a gaming simulation is to be used in a distributed, or multi-site mode, provision must be made for the participants to communicate with each other as well as with the computer simulation. It is also desirable to store and classify all such communications by subject, simulated time of transmission, real time of transmission, participant name, and role name so the communications can be reviewed by interested parties as needed during and after the gaming simulation. This storage and classification system should also apply to messages transmitted between the computer simulation and the participants, thereby providing a complete record of the dialogue for review in a systematic fashion.

Since all communications should be classified by subject and participant role, the game director should be able to monitor selected interactions and modify the text before it will be sent to its destination, if such modifications will be required or desirable. Gaming simulation management system should also contain facilities for specifying dependencies between subsystems and roles within subsystems. A provision should be made to include simulations of non-playing roles and to utilize these simulations to provide time-critical decisions if a participant is unwilling to do so after being notified. Furthermore, a priority system is included which provides faster computer response to participants with a heavy decision agenda, and slower response to those with a light decision agenda, thereby attempting to move all participants through simulated time at similar rates.

7.3.4 Modularity of Submodels

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. The distributed computer simulation system mentioned before may well achieve this goal.

Each subsystem should possess the following characteristics and capabilities:

(a) an independent data storage area inaccessible to procedures in other subsystems,

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

(c) control over the advancement of simulated time in the subsystem,

(d) 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.

7.3.5 Distributed Computer 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.

The increasing availability of inexpensive, powerful micro-computers results in a need for the incorporation of support for distributed computing, that is, a sharing of the computing activity by a number of computers. For instance, by using intelligent terminals which incorporate small computers with graphic display capability, much of the extensive dialogue between participants and the simulation can be condensed to transmission of control codes between computers.

While this mode of operation does not eliminate a need for the capability to transmit rather lengthy messages and data in special cases, it does greatly reduce the level of communications traffic needed to support a distributed game and makes interactive gaming and its graphic display financially feasible.

7.3.6 Communications Among Geographically Dispersed Participants

The disciplinary scope of a gaming simulation is not only influenced by the complexity of the system being modeled, but also by the level of detail the game designer wishes to include. The broadening of disciplinary scope to increase detail usually increases the difficulty of assembling a multi-disciplinary staff to direct the game. Elements of interpersonal cooperation and competition are also often central to the processes being modeled for gaming simulation. It is also often desirable to have the players geographically distributed rather than centralized.

When the richness of a multiple participant game is desired, computer can provide a communications and coordinating facility among the players. Computer can create common simulated environment for all participants and serve as a message processor for communications among participants in the game. The addition of computer conferencing system mentioned before provides the participants with a structure system of communication without making it necessary to leave the gaming environment.

In addition, some of the most important information a real world decision maker has available is his record of the communications between the key actors in the system. Computer conferencing system will record and classify all communications among participants, and be possible to retrieve and study these communications on a selective basis.

7.3.7 Flexible Gaming Management

Long duration, multi-session gaming simulations which are to be used for both pedagogical and experimental purposes need a flexible capability to preserve the status of the simulation pending its future restart. Computer can preserve the current status of the simulation when requested to do so by a participant or game director. The computer can present at a subsequent session a brief summary of action in previous sessions as part of the initial scenario. Using this capability, gaming sessions can be of varying duration, depending on the schedule of the participants.

Additionally if the game director wants the participants' experience to focus on a particular period in simulated time, it is possible for the game director to play the game to the beginning of the desired period and, using the status saving feature, initialize the game for the students at the chosen point in simulated time. Finally, the capability to preserve the status of the simulation at will means that a participant can replay the game over selected portions of simulated time by saving the status of the game at the beginning or the selected period, playing the game forward to the end of the period, and then restarting the game at the beginning of the period for another trial.

7.3.8 Experimental Capability

When a participant is attempting to understand the behavior of the model or evaluate the impact of a particular decision on the simulated system, he needs to be able to analyze the output of the gaming simulation in a systematic fashion. If all participant decisions are reached and implemented through interaction with the computer, a complete record can be kept of those interactions. Furthermore, if the results of those decisions are calculated by the computer model before being communicated to the participants in the game, those results can also be made available for analysis. Computer can also facilitate the analysis of data collected during simulation run if a rudimentary content analysis capability and a statistical package are integrated into the computing facility.

7.3.9 Interactive Graphic Capability

Most environments which are complex enough to warrant gaming as an educational or research tool are hard to deal with if graphic techniques are not used to supplement spoken and written communications.

The more complex the gaming environment becomes, the more important good graphic techniques are to the success of the gaming simulation. If the computer is to be used, graphic techniques must be a part of the panoply or media used for communication. Furthermore, these graphic capabilities should be integrated with the data analysis capabilites provided in the gaming simulation. Finally, the graphic should be interactive, so that the participant should be able to use graphic techniques to input decisions and use time-phased graphics to monitor change in the simulated environment over simulated time.

The routines that manage the textual communication also will be capable of storing and displaying graphic communications, including displays which are partially preformatted and partially dynamic. Provision should be made for graphic response from the participants using a variety of graphic input devices such as a graphic tablet, joystics, or light pen. One participant should also be able to send a graphic display to another participant. The recipient will then be able to modify the display while the sender observes the modification.

Thus the graphic capability will provide for inter-participant communication as well as communication between the computer simulation and the participants.

7.3.10 Statistical Analysis Capability

A real world decision maker is usually able to gain information on which to base his decisions by collecting and analyzing relevant data. A gaming simulation should give the participants the same capability. Furthermore, the ability to subject the output of the simulation to statistical analysis is an important debugging and validation tool. The results of the statistical analysis should also be displayed graphically.

In both the areas of statistical and textual data, a given participant should only be allowed access to certain data and the game designer should be able to specify the range of access to the statistical data and textual messages available to each participant.

7.3.11 High Level of Transparency

Typically, as the level of detail and complexity of the gaming simulation increases, with a concomitant increase in the complexity of the computer component of the model, the simulation model becomes more difficult to understand.

One of the most severe criticisms of large scale models results from the inadequacy of the available documentation on their assumptions and operation. Documentation of the computer simulation element of a gaming simulation should be produced as the computer programs are written. If well-structured programs are produced with explanatory comments on each block, these comments should be available to game participants. During use of the gaming simulation, a user will be able to get specific documentation for any section to get specific program.

The graphic display capability, in conjunction with an automatic flowcharting system, will serve to make this documentation comprehensive and clearly indicate the relationships among blocks in the program. Computer can then alleviate the opacity of complex models by making documentation of the internal workings of the model available to the participant.

7.4 Summary

In view of the revolution in communication and computing technologies which has taken place in the last decade, the potential usefulness of computers in gaming simulation extends beyond the restricted arena of calculation, record-keeping, and modeling. Indeed, the computer can now assist with the interface between the participants and the computer model in such a way as to greatly increase the effectiveness of man-computer simulation as a research and teaching tool.

The distributed interactive gaming simulation coupled with computer conferencing system will then become the most sophisticated and integrated future communication media and/or language.

V. GLOSAS PROJECT

1. Introduction

In order to analyze national and international policy-makings on global problems of the socio-energy-economic systems, it is recommended here that a quantitative, predictive approach should be taken with the integrative usage of computer simulation coupled with new computer network technologies. High credibility of the computer simulation study can be achieved by (1) the construction of various component simulation models by experts of individual countries, and (2) the disaggregation of crude, macro-models into micro-industries and -social systems.

However, (1) the experts usually intend to construct their models with their preferred programming languages and computers at their premises, and (2) the individual, disaggregated model tends to become large occupying even a single computer core memory available today. In order to keep the models as much intact as possible for their credibility, it is then necessary to interface those component models resided in geographically distributed dissimilar computers by telecommunication lines even including via satellite. These models will be built by interdisciplinary teams in each country with interfaces cooperatively worked out by them using the global computer conferencing system.

Such an interface can only be accomplished by distributed simulation system on a global packet-switching computer network. Interactive gaming simulation study will also test the effectiveness of multi-national policy design intended to solve global conflicting problems.

2. Scope

The GLObal Systems Analysis and Simulation (GLOSAS) Project (61, 62) was conceived as a world-wide, multi-national response to aid in solving the problems plaguing mankind today.

The purpose of the GLOSAS Project is to develop an international, interactive "peace gaming" simulation of energy, resources and environmental (ERE) systems, or the so-called socio-energy-economic systems.

This global simulation system will intend at its ultimate stage to provide decision-makers in government and industry with comprehensive information in an international framework to evaluate the effects of possible policy-decisions of different countries and groups of countries on each country's energy, resources, pollution, domestic economies, as well as international trade and monetary systems among all of the countries.

This simulation will be constructed with the integrated utilization of the latest global public VANs assisted by satellite telecommunications, computer conferencing system, and world-extensive distributed computer simulation and data base management systems, simultaneously running different area and sector models to solve the problems associated with complex socio-energy-economic systems.

The initial development stage of the GLOSAS Project will be a joint undertaking of Japan and the United States, involving the forging of new dimensions of international and interdisciplinary co-operation 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.

3. Domain

3.1 Subjects

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.

The domain of this project at first is focused on the supply and demand of energy and resources, and on the environmental control in relation to the structures of industries and socio-energy-economic systems.

3.2 Geography

The GLOSAS Project at the initial stage is concerned with Japan, the United States, the oil producing countries and the rest of the world.

Within the Japanese-United States's parameters of the GLOSAS Project, a joint energy policy is being developed through Japan/U.S. International Energy simulation models of both countries that will enable Japan and the United States to achieve the most efficient distribution in their respective economies of the gross volume of oil production available from the oil-producing states. A similar world energy policy based on a World Energy simulation scheme is a logical future step to this joint Japan-United States plan.

After proving the basic concept and technical feasibility of this project between Japan and the United States at the initial stage, other countries such as Canada, Australia, European, the communistic and developing countries will also be invited to participate.

3.3 Prediction Period

On the verge of depleting precious and widely used crude oil, advent of new alternative energies is the vital necessity and everyones' longing. It is however difficult to expect such appearances in the near future, due to their requirements on large amount of capital and human resources.

Consequently, computer simulation studies of energy policy should include the effects of the research and development of new alternative energies upon the domestic and international economies. The simulation should therefore predict through over 25 years, the expected time duration for the research and development of new alternative energies.

4. 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 in such a way that computer conferencing system can be used in conjunction with the interactive gaming simulation.

(4) To construct and subsequently interface adequate simulation submodels of the supply and demand of energy and resources, and the environmental control 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 simulation of the 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 in full cooperation to obtain appropriate consensus on possible global energy policies.

Namely, the aim of the total gaming simulation is the analysis of energy policy affecting the domestic and international economies of Japan and the United States.

(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, for the use of the system 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 distributed interactive computer simulation system 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.

5. Methodology

For the sake of simplicity, this project at initial stage will be limited mainly to utilize models built by systems dynamics methodology during the development of interfacing software necessary for the distributed computer simulation 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 as integrating the other conventional ones, such as econometrics, input/output method, linear programming, policy delphi, cross-impact matrix analysis, etc., with the use of the distributed computer simulation system.

The behavioral assumptions are difficult to model even in the foreseeable future. The approach of the GLOSAS Project is to insert a-man-in-the-loop, as the pseudo-policy-decision-maker as similar to a trainee pilot in a flight simulator with interactive gaming simulation mode, or at most, to guess them probabilistically with cross-impact matrix analysis.

6. International Cooperation on Modeling

The GLOSAS Project will forge ahead new dimensions of international and interdisciplinary cooperation in recognition of the interrelated character of today's global problems and the notion that their solutions to world problems lie in joint planning and application of the technologies and intellectual resources among nations. The GLOSAS Project will, therefore, envisage a distributed responsibility of participants in various countries and disciplines, for the integrated construction of a globally distributed computer simulation system.

Subsequently, the models of energy use, resource allocation, national economy, foreign trade, international monetary system and environmental impacts, will be built by interdisciplinary teams in both Japan and the United States, with interfaces cooperatively worked out by the two teams using the computer conferencing systems, to achieve good communication for coordinating among researchers of this project as well as modelers and users (interactive gaming players), who will reside at various geographical locations.

Research will be carried out with university, industrial and governmental participants to insure the use of reliable data and the testing of relevant policy alternatives, as organizing working teams of specialists for each component in both countries. Each team will conduct systems analysis and build models and databases.

7. Hardware and Software

7.1 Hardware

Use of the following computer networks will be considered for this project;

(a) ARPANET
(b) TELENET
(c) TYMNET
(d) The extensions of TELENET and TYMNET to overseas countries and their interconnections with those countries' domestic public VANs.

This project intends to make deliberate use of multiple dissimilar computers connected to these networks, with the execution of component models in them concertedly, parallelly and simultaneously.

Because of the similarity between ARPANET and TELENET, and also of the global public nature of TELENET and TYMNET, the protocol software interfacing component simulation models will be sufficient for the GLOSAS Project in the foreseeable future, if the protocol software will be applicable with those networks.

7.2 Software

Following continuous system simulation languages will be considered first for this project;

(a) DYNAMO
(b) CSSL
(c) ACSL
(d) CSMP

When the interfacing software of the distributed computer simulation system is developed and applied to the socio-energy-economic system, the simulation will take a gaming mode with the interactions of the executing simulation system by actual human (or simulation researachers, or the so-to-speak, pseudo-policy-decision-makers), who will be located in various countries among which there are large time differences, e.g., almost 12 hours between the U.S. and Japan.

Since the participating researchers will be able to work only during their day time, the simulation models of various countries can be coupled loosely, but not tightly. Consequently, the performance of the proposed system and transmission delays of state variable communication would become secondarly importance. (As told, advanced packet-switching communication equipment of TELENET and TYMNET, which are now customarily used for the global public VANs, can compensate such transmission delays via satellite.) Also, computers would not be idle while waiting for required information, since the models can easily be instructed to be out of computer core and be stored in disk, yet ready for re-loading upon next instruction.

Because of this basic nature of the proposed, loosely but automatically coupled internationally distributed socio-energy-economic simulation models, the problems of different word lengths, data structures and time scales, etc., which result from using both different computers and different languages, will be solved reasonably without much difficulties. This will be accomplished by writing the interchanging state variables with pre-specified formats into a pre-determined central data base and also by using the vertual network file system mentioned before.

Also, because of the intention to make deliberate use of multiple computers in various countries in the future stage, with overseas associated groups with their funds to cover their parts, comparison of costs of executing a model on various distributed computers versus on a single large computer will not be necessary.

8. Scheme of Distributed Computer Simulation System

Referring to Figure 6, suppose the rectangular boxes are dissimilar computers of global public VAN, having a possible international linkage among them via satellite telecommunication line.

Component models A and B are dynamic ones with their own data bases which can only be written by their associated models, but not by other models. They can also be read only by the data base of Model X.

Model X is a static one without integration of any state variables. It will act as an execution program. Its functions are;

(1) control of total simulation, such as integration time step in other models, print-out interval, interface with conferencing system, etc.;

(2) collection of selected data from other models in historical sequences;

(3) common data base to be used by other models, etc.

At the start of simulation execution, initial preparing calculations will be made within Model X. Then, necessary variables will be transferred to other models. The initial sectors of continuous system simulation languages with which Models A and B are written, will first compute initial values of every variables in each model. Values of any necessary variables will also be exchanged among models through Model X. Model X confirms that every model finished their initial calculations.

Then, each model will advance one integration time interval with its own integration scheme. However, there will be no data exchange among models during this time interval. After every model has computed derivatives of its state variables, it will multiply them with the value of the integration time step in order to come up with their new values of the state variables at next time point. Each model will modify only their own data bases with the new values.

Then, Model X will ask Model A what values of state variables of Model B to be transferred to Model A. Model X will convey them to Model B. Model B will look for them in its own data base. If found, Model B will send them to Model X. Model X will store them in its own data base first. Model X will

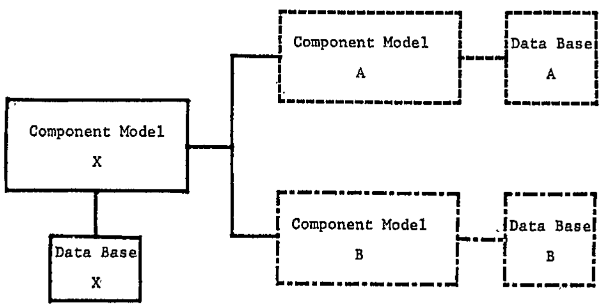

Fig. 6

Scheme
of
Distributed Computer Simulation System

then tell Model A that the wanted new values are stored in Model X's data base. Model A will then read the necessary values from Model X's data base. Data transfer from Model A to Model B will also be carried similarly via Model X and its associated data base.

This scheme may necessitate to build large data base of Model X in the future. However, it will be simple to accomplish, and data bases of Models A and B will not be impaired by each other. This scheme will also enable us to utilize the data base of Model X for overall analysis.

In summary,

(1) The above scheme will make certain that only Model X has the capability to read only data bases of Models A and B. Models A nor B cannot read nor write on each other's data base. Model X can include a program to convert state variables among Models A and B. Model X can also include programs of statical, dynamic, and statistical analysis of state variables of Models A and B;

(2) Models A and B will be independently at equal level, and will be subordinate to only Model X;

(3) Models A and B will progress concurrently with their own integration scheme, but with the fixed integration time step given from Model X. At each step, they will interchange data with other model through Model X, and then proceed to the next time step.

9. Interactive Global Peace Gaming Simulation

9.1 Need

The GLOSAS Project is concerned with the global problems of appropriately allocating energy, food, natural resources, and global modifications of industrial structures, in the order.

Here, the "appropriate", rather than "optimal" allocation is preferred, since the latter may apply to only one objective being satisfied. This is due to the fact that social, especially global, problems involve many different, conflicting interests. Their solutions are not to optimize one objective after selecting it among others, but to seek consensus among participating parties.

For their appropriate allocations, the GLOSAS Project emphasizes the importance of global energy policy analysis more than the increases of their productions. This is because those precious resources are limited on our earth, and their productions are near to limits of scale-merits. Since new alternative energy sources will also take 30 to 50 years to be commercially available, it is the first step of human survival in the immediate future to utilize effectively old energy resources, particularly crude oil, with appropriate allocations prior to the appearances of new ones. Unless otherwise, human beings may be destroyed by a severe "tug of war" of limited old energies well before appearances of new ones, and huge capital investment on the research and development of new alternative energies may be wasted without use.

Also, most computer simulation predicts, say, to the year 2000 the economic and energy behavior without policy interaction from the initial values, say, at the year 1980. This is illogical, because change in the model due to policy changes must be made in reality wherever necessary, such as at the time of the last oil embargo.

It is therefore suggested here that the distributed computer simulation of energy—economic activities in various fields and countries need to be made with man-machine interactiveness, whereby the men are the experts of those fields and countries who insert the pseudo-policy-parameters to the simulation models whenever necessary, while the execution of simulation models are made. This is the so-called "peace gaming" simulation (66) similar to the "war games" practiced by military strategists (42).

The aforementioned computer conferencing system will then perform the role of verbal communication media among energy policy planning experts of various countries. The conduct of such interactive simulation on current global problems by experts distributed worldwide, utilizing global computer network, will accelerate mutual understanding among countries. Conflicting interests resulting in a "tug of war" or other conflicts over the limited resources, such as the precious crude oil, will be minimized.

9.2 Global Peace Gaming Simulation Mechanism

The outlines 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 7. Each block in the figure represents dissimilar computers located in the United States and in Japan, as the 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. The flow of petroleum from oil producing countries will be regulated by their own decisions as well as by decisions made by the pseudo-decision-makers of Japan and the United States. 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.

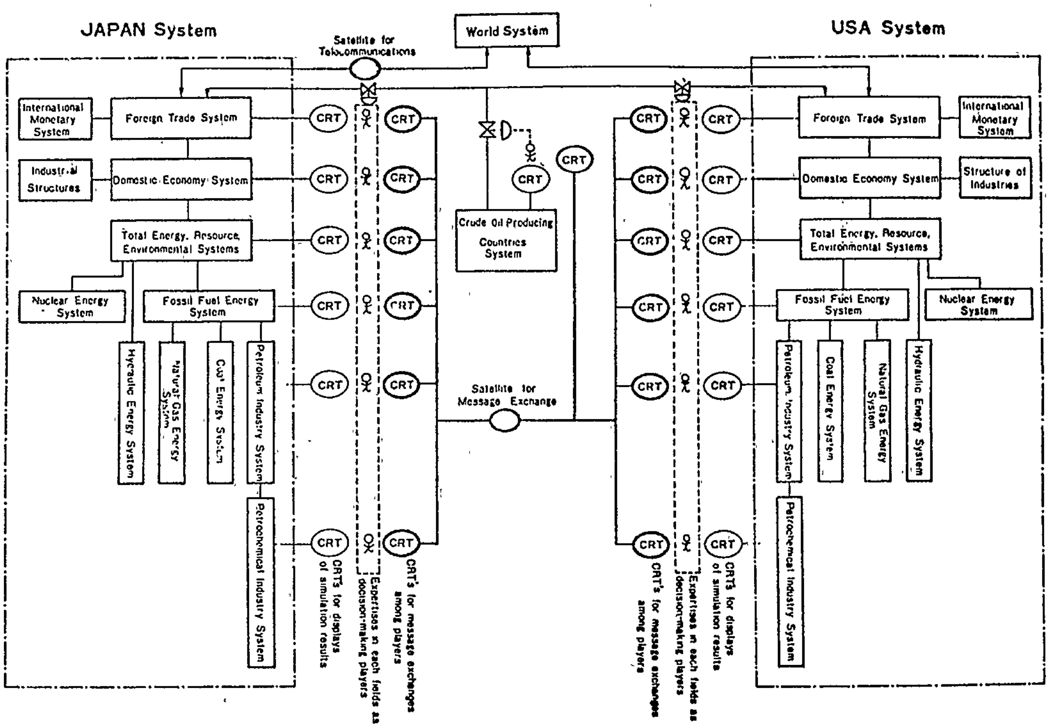

Fig. 7

Structure
of
Integrated Models and Communication Network

The communication linkages are also shown in Figure 7. 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 a different computer other than the ones processing the simulation models.

After interfacing the respective Japanese and the United States energy and related models, the GLOSAS Project proposes to conduct multi-national interactive gaming simulation in computer-to-computer conversational mode via the global computer network. Namely, once after simulation started for a time period, results will be shown on display units. Suppose if pollution in Japan exceeded a certain allowable level, 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-alternative-policy parameters. New parameters will then be fed to simulation models which will be executed until new crisis appears. The process will be repeated for the study of global policy analysis with international cooperation of experts in the United States and in Japan.

10. Recommended Procedures

10.1 First Phase Demonstration Project

The newly establishing global public packet-switching computer communication network, the so-called value added network (VAN), will make it possible for geographically dispersed dissimilar computers to perform distributed data processing (DDP). The DDP applied for simulation is the distributed computer simulation system (DCSS). This first phase demonstration project will develop a standard protocol software necessary for the DCSS with the use of virtual network file system mentioned before.

The software will enable to interface component models written in various simulation languages, which models will be resided in the 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 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 corporate management, socio-energy-economics, etc.. 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 corporation and international economy. Cooperation to share valuable resources is the basic principle of this project.

Recommended step-approach procedures are:

(1) Establish project teams of very small, but highly skilled computer simulationists on social systems in the participating countries.

(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) Study of requirements for constructing standard software of distributed computer simulation system which will include various protocols, commands, handshaking procedures, common data bases, display procedures, message exchanges, etc..

(4) Conduct the following first phase demonstration project.

Since the main purpose of this project is to develop software which interfaces models written by various continuous system simulation languages, this phase project will not attempt to create new models unless necessary. Rather, it will try to interface existing models developed elsewhere.

Thorough investigations of various systems dynamics socio-energy-economic simulation models concluded that the World Dynamics-II model (17) of Professor Jay Forrester of MIT 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 distributed computer simulation system.

During this phase, therefore, the World Dynamics-II model already programmed in DYNAMO simulation language with 5 component sectors will be used.

(a) 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 of the DEC computers which TENEX was once used for McROSS system development by R. H. Thomas (50).

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

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

(d) Make the languages capable for interactive simulation.

(e) Execute those models interactively, cooperatively and simultaneously.

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

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

This project focuses on the development of interfacing software. The following related fields need to be concerned;

(1) Data communication protocol,

(2) Continuous systems simulation languages,

(3) Operating systems of dissimilar computers.

Since newly, yet well, established packet-switching data communication protocol, such as X. 25, etc., is now available as an international standard of global public VAN, the interfacing software to be developed by this project will be at a higher level than the data communication protocol.

Consequently, major role on the development of the interfacing software will be played by the persons who are familiar with the continuous system simulation languages, since they are also familiar enough with the operating systems of major dissimilar computers.

As mentioned elsewhere above, this phase project is based upon the notion of necessity of distributed computer simulation system in order to simulate faithfully the mechanism of international socio-energy-economic systems. 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.

Consequently, the effort of this first phase demonstration project is to make a first, small step toward this goal as developing 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 appropriate for the specifications of data manipulation and model formulation, and explanation and interpretation of the socio-energy-economic systems.

This may seem analogous to the follwoing;

(1) Econometrics was developed after computer was created.

(2) Surgical medicine was improved when anethesia was developed

The successful demonstration of this initial phase project will 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.

10.2 Second Phase Project

Test the protocol software developed by the first phase demonstration project, with the use of the models of energy economics of Japan and of the United States, and agricultural economics of the United States.

The aim of the total simulation is the analysis of energy policy affecting the domestic and international economies of Japan and the United States.

In order to increase credibility of the simulation results, those models are better if they are built by experts of each country. For the sake of simplicity, this phase project will utilize mainly models built only by Americans. However, the following models may be considered for this phase project:

Japan

(a) Stover, J. G.;
"Energy Policy Modeling with Probabilistic Systems Dynamics : A Japanese Case Study"; Paper presented at the 1974 Summer Computer Simulation Conference, Houston, Texas, July (1974).

--- This model interfaced systems dynamics model of Japanese economy with cross-impact probabilistics model.

(b) Hori, H.;
"Dynamic Properties of a Japanese Macro-Economic Model and Effect of Exogenous Shocks"; 1973 Summer Computer Simulation Conference Proceedings, Page 1016 to 1025.

--- This model was built by systems dynamics methodology with econometric consideration.

U.S.A.

(a) Levis, A., et al;
"Project AGRIMOD";
Systems Control, Inc., Palo Alto, California, (1976).

--- A systems dynamics model about the U.S. agricultural economics which project was sponsored by National Science Foundation.

(b) Baughman, M. L.;
"Dynamic Energy Systems Modeling -- Interfuel Competition";
Energy Analysis and Planning Group, MIT, September, (1972).

--- A systems dynamics model sponsored by NSF.

Oil Producing Countries

(a) Utsumi, T., et al;
"Preliminary Study on International Oil Energy Policies";
1975 Summer Computer Simulation Conference Proceedings, Page 1371 to 1380.

--- This is a combination of Hori's Japanese systems dynamics economy model, a linear programming model for Japanese oil policy, and econometric models of oil producing countries.

10.3 Third Phase Project

Invite experts of Japan and the United States to interface their models via global public VANs, in order to perform internationally distributed, interactive "peace" gaming simulation of global socio-energy-economic system for multi-national policy analysis.

(1) To conduct sysetms analysis of energy usage in their countries by those teams with the use of the global computer conferencing system.

(2) To 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 their own countries, but the interface among them should be designed to coincide with each other for the future consolidation.

(3) 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 model for the country.

(4) Once every country's models have been constructed, congregate them using 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 distributed computer simulation system in various fields in domestic or international scale.

11. Presumptions

Following very basic presumptions are implicit to this GLOSAS Project:

(1) Simulation study requires high and reliable credibility.

(2) Socio-energy-economic system consists of component systems, e.g., micro-economic systems or various industries, etc., in a domestic scale, as well as macro-economic systems of various countries in an international scale.

(3) High credibility can be achieved only when each component system (or country) is simulated by the expert of the system (or country).

(4) The simulation model of each component system will be 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.

(5) The simulation model of each component system needs to be interfaced each other into one coherent, integrated system in order to obtain comprehensive results, since each component system is highly interrelated with others.

(6) In order to interface the simulation models of various component systems (or countries), which are constructed by the experts, their dissimilar computers have to be interconnected.

(7) The simulation of socio-energy-economic system is synonymous to the policy analysis, i.e., the test of "what if" assumptions of various policy alternatives.

Since the policy is often made or altered in the real world, the simulation model of the real system has to have the capability of interactive peace (instead of war) gaming mode for the policy analysis.

(8) The expert cannot congregate at one place for a long period.

(9) The computer conferencing system will be useful and economical (1/5 of Telex cost) for the written word communications among the experts:

(a) on their cooperative system analysis and model building,

(b) on their use of the interactive gaming simulation models for policy analysis, and

(c) on the administration of the project.

(10) Because of interdependence of various complementary models, the socio-energy-economic systems must be viewed and analyzed in a global scale.

International cooperation of this project will not only make possible the complex large-scale simulation with high credibility, but also save maney as avoiding duplicate construction of the complementary models.

(11) The global public VAN now extending to major overseas countries will be;

(a) most versatile for the interconnection of distributed dissimilar computers, and

(b) most useful for the international coordination of experts in various locations and countries.

12. Summary

The antinomy of totalitarianism is democracy, wherever 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.

Integration of the complementary models mentioned in the previous section may be difficult, especially when they are to be kept intact as much as possible during the integration process, possibly because they are incompatible with each other. The computer utility technology to be developed and demonstarted by the GLOSAS Project will attempt the integration of complementary individual models and data bases with virtual network file system, which will be constructed in various languages and stored in geographically distributed dissimilar computers perferred by experts of each discipline and country, but connected on a global computer network.

With the advent of global computer networks, the credibility of simulation study can be improved significantly. This will be done by the expansion of domain of simulation models by the combinations of submodels and complementary models. Each of these models will be constructed interdisciplinarily by experts in different locations, with their preferred, but geographically distributed computers and programming languages. Most effective will be the use of distributed simulation and database systems.

Communications among the experts will be closely maintained by a computer conferencing system during the model building, interfacing, and execution of the models in interactive mode, from terminals at various locations, sometimes even in overseas countries.

The interactive simulation has become an effective means of policy-analysis and personnel training in managment, social, economic and political sciences. Computer simulation coupled with satellite telecommunications and the global computer network provides a capability by which we can test the effectiveness of international policy designs intended to solve global problems. These technologies together will create in effect a world-extensive model of a large number of countries, which will be useful in analyzing problems and providing solutions. With the global "peace" gaming simulation to be created through this integrative use of the latest technologies, it will be possible to achieve global policy-analysis so that all countries can mutually benefit and coexist with more friendly understanding.

VI. PROGRESS AND ASSOCIATED ACTIVITIES

1. Global Public VANs

The establishmen of global public VANs is a mandatory necessity for the GLOSAS Project. Here, the VANs have to be "public" instead of "private" because of high cost of overseas leased telecommunication lines (e.g., $30,000/month for 9,600 bits/second line between the United States and Japan).

The public VANs also provide easy access to host computers through ordinary telephone from anywhere the global public VANs have been established. The international standard protocols also make possible to interface dissimilar host computers with the public VANs, whichever computers the experts of various disciplines and countries prefer.

Since the initial presentation of GLOSAS Project at 1972 International Computer Communication Conference in Washington, D.C., (60), the writer has been advocating, promoting and assisting the establishment of the global public VANs, in cooperation with the U.S. international record carriers (IRCs), VAN carriers and communication authorities of overseas countries, resulting the extension of the U.S. public VANs to more than 25 major countries and regions as listed before.

The difficulties encountered here are not technical but rather political and business natures because of inconsistent communication regulations, trans-border data flow regulations, and protection of computer and telecommunication hardware and software industries and information industries in some countries.

High speed computer-to-computer communication via the global public VANs can now be possible between the U.S. and Canada and between the U.S. and the U.K., and will be so among other countries in due course. If the protocol software of the virtual network file system described before had been fully developed, GLOSAS Project could be realized at least among those three countries at the present.

2. Global Information Services

More than 70 billion dollar worth of computer software and services exists in the United States and Canada alone. Similar valuable assests exist in European countries and Japan. The writer however noticed during his stay in Japan from 1972 to 1976 that there was a great gap between the state-of-the-arts on applications of computer and communications in Japan and the United States. He then thought why not to have overseas people access directly the superior computer information of the U.S. via the global public VANs, avoiding the inventions of new wheels.

With this notion, the activity of Global Information Services (GIS), Inc. was born, as a spin-off and a commercial application of the GLOSAS concept -- the promotion of worldwide understanding and cooperation among people of various countries through technology, information and knowledge transfer via the global public VANs (72). The GIS activity helps to make international and national communication and VAN carriers justify the establishment of the global public VANs as a viable business, and is now helping them in accelerating the rapid realization of the global network.

GIS provides, in collaboration with its overseas counterparts (currently, mainly Japanese), an international business network for wholesale and retail marketing of products and services of information, communication and computer, utilizing the newly establishing global public VANs.

Essentially the GIS business is to provide a "shared international marketing capability" which will provide worldwide market access at significantly reduced costs to both suppliers and end-users of computer-based products and services, which are available from North America, The United Kingdom, and other countries. Matching users with vendors, locating desired products and services, performing market surveys and coordinating intracorporate information systems are typical GIS functions.

Small to medium-sized North American vendors can market their services in Japan, via newly established International Computer Access Service (ICAS) of Kokusai Denshin Denwa (KDD) of Japan, without initial expenditures for high cost, private transpacific data communication lines and facilities.

In order to cope with the peculiarities of Japanese society, a new distribution channel is now being established by GIS and its Japanese counterparts. This channel will provide the vendors with minimum risk and broad market for economy-of-scale as well as cost-effective technical support and after-care services to end-users, without large investments for their own subsidiaries or for joint-ventures with Japanese companies. Japanese counterparts also can start their operations with minimum investment and maximum flexibility, yet potential growth in the future.

Japanese end-users will also be benefited with higher degree of freedom to choose among varieties of computer services available from many vendors, rather than only a few large vendors who could afford expensive private communication lines and facilities and joint-venture investments.

Opening up these new channels of communications and distributions of North American computer services and products will provide an important new avenue for East/West trade and will be a significant benefit to Japan as well as the United States.

The promotion of international sales of the U.S. computer services by GIS and its Japanese collaborators will subsequently augment the utilization of not only the U.S host computers but also of the transpacific and domestic communication lines of the U.S. and Japanese VANs, thereby profiting all the parties involved.

The GIS activity may also become a precoursor to stimulate interest of overseas people in understanding the values of global computer communication networks and overseas computer services, and consequently, in participating with GLOSAS Project by interfacing their countries' socio-economic simulation models via the global VANs in the future.

3. Virtual Network File Systems

As described before, the virtual network file system is now being developed under the auspices of Institute for Computer Sciences and Technology (ICST) of the U.S. National Bureau of Standards (NBS), as one of the standardized protocols for various U.S. federal computer networking for the communications among distributed application programs and data bases, etc..

Currently, it is said that the Common Command Language (CCL) and Common Command Language Protocol (CCLP) of the virtual network file system have been implemented in several PDP-11 computers of TELENET. In the near future, the system will be implemented into various dissimilar computers.

Recently, Japanese Ministry of Posts and Telecommunications also announced an all purpose Computer Communication Network Protocol (CCNP) which will enable computer-to-computer conversations among application programs in dissimilar computers over public packet-switching network, such as DDX-PS (domestic) of Nippon Telegraph and Telephone (NTT) and VENUS (overseas) of Kokusai Denshin Denwa (KDD) (33).

The application of these CCL and CCLP with a virtual network file system to distributed computer simulation would be to make each file management system in dissimilar computer operated cooperatively together as well as each system working with its associated submodel resided in the individual computer. Multi-national distributive, interactive "peace" gaming simulation will be possible only after the development of the interfacing software, such as CCL and CCLP with a virtual network file system.

4. Computer Conferencing System

There are now over 50 computer service companies offering terminal-oriented electronic mailbox services with time-sharing mode throughout the United States and Canada. Though the distinctions between the electronic mailbox system and computer conferencing system have recently blurred, the most notable ones for the latter are HUB system of Institute of the Future (27), PLANET system of INFOMEDIA (31) and EIES of Computerized Conferencing and Communication Center (CCCC) of the New Jersey Institute of Technology. They have been used for "invisible" conference and group meeting through TYMNET or TELENET in the United States, Canada, Europe and even in global scale with the combined use of Telex, which connection with TYMNET and TELENET was described before.

The writer was once engaged with a gaming on international affairs conducted by POLIS Laboratory of University of California at Santa Barbara (34, 35), with the combined use of G.E.'s worldwide time-sharing service network and ARPANET in the United States. The software of the computer conferencing system was developed specially for this purpose on the G.E./Mark III computer located in Cleveland, Ohio.

The political science departments of many universities in the U.S., Japan, England and Belgium were assigned to act as governments of various countries. According to a scenario, students exchanged diplomatic messages from Tokyo, London and Brussels via the GE network, which were then transmitted to other universities in the U.S. via ARPANET, and vice versa. This attempt in 1973 might be the world first gaming in international scale, which excited participating students and professors greatly.

Interactive gaming simulation naturally requires involvement of gaming players (or pseudo-policy-decision-makers) around the computer network. They must communicate with each other by written language, say English. Such communication can be accomplished with extensive use of an existing computer conferencing system around the network.

An appropriate scheme of interfacing the distributed, interactive computer simulation system with the computer conferencing system will be formulated during the development of the distributed computer simulation system with the use of the conferencing system. This necessity of such an interface between both of the simulation and computer conferencing systems for GLOSAS Project was favorably supported in the NSF sponsored report (41).

5. GLOSAS Project

GLOSAS Project has been quoted in various articles (9, 10, 11, 18, 25, 41, 48, 49, 55), though its actual commencement has to be waited until when the high speed computer-to-computer communication linkage via international public VAN between VENUS of KDD and DDX-PS of NTT in Japan and TELENET and TYMNET in the U.S. will be made sometime in 1981 and also until when CCL and CCLP of the virtual network file system will be developed in the near future by the U.S. National Bureau of Standards.

Kaufman (61) commented GLOSAS Project as "a quantum jump in the scope and complexity of modeling".

6. Simulation Models for GLOSAS Project

In recent years there have been noticiable developments in the activities of socio-energy-economics simulation in micro- and macro-aspects. They are the following;

6.1 GIS/APSO

GIS/APSO is the acronym of Global Information Services/All Purpose Simulator and Optimizer, which was called previously SWAPSO (Stone & Webster All Purpose Simulator and Optimizer) (56).

Incidentally, during the construction of SWAPSO Program more than 10 years ago, the writer encountered with considerable difficulties in combining various large-scale simulation and optimization packages in a single computer. Then, a notion came to him why not to let them reside in several computers as much intact as possible, and to interconnect them via data communication network. The notion has been enhanced to become GLOSAS Project proposed here.

6.1.1 General Organization of GIS/APSO

Referring to Figure 8, GIS/APSO consists of several software package blocks.

Simulant block consists of two sub-blocks, (1) CSMP for continuous system simulation and (2) GPSS for discrete system simulation. [The later has not been combined as shown with dotted line, though such connection was once planned in the spring of 1973 as replacing CSMP with NGPSS as mentioned in the reference (37).]

During the execution of CSMP model, Sub-blocks (3) and (4) will be called at a certain time interval. Sub-block (3) is the input/output (material or energy) balance program. Sub-block (4) is the optimizer which can be a linear programming (MPX) or a non-linear optimization program.

Also, during the execution of CSMP model, Sub-blocks (5) and (6) will be called at a certain time interval. Sub-block (5) is a statistical (BMD) program to analyze actual data read into CSMP model at the initial stage or sampled data of simulated variables. Sub-block (6) is a kind of data base of a cross-impact matrix study for probabilistic occurence, which is produced independently by delphi method.

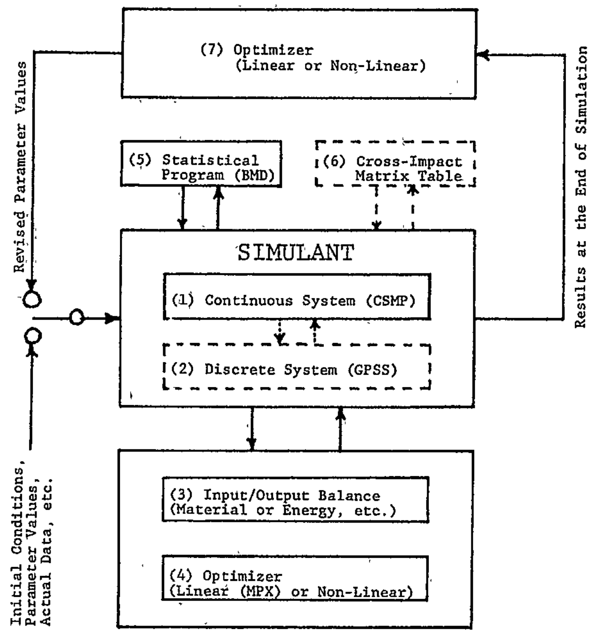

Fig. 8

Schematic Diagram of GIS/APSO

After terminating the execution of the CSMP model, the simulated results will be passed on to Sub-block (7) of optimizer which can be a linear programming (MPX) or a non-linear optimization program. Revised initial conditions or parameter values by the optimizer will be fed back to the simulant, and the process will be repeated until a certain objective will be satisfied by the optimizer.

Although the continuous system was modelled with CSMP, it can be done with other continuous system simulation languages, such as ACSL, CSSL, DYNAMO, etc..

6.1.2 Applications

Various applications can be made with the sub-blocks.

(1) Supervisory Digital Control (56, 57, 58)

The combination of Sub-blocks (1), (3), (4) and (5) was made to simulate a supervisory digital control (SDC) of a chemical refinery which is the combination of a petroleum refinery and petro-chemical plants.

Sub-block (1) was to simulate the process dynamics of the refinery and plants. Sub-block (3) was the combinations of many FORTRAN process design programs and material balance program. Sub-block (4) was to set the set-points of direct digital controllers (DDC) at a certain time interval. This sub-block was IBM's MPX linear programming optimization. Sub-block (5) was used to analyze actual data read into Sub-block (1).

(2) Reaction Kinetics Study (59)

The combination of Sub-block (1), (3) and (7) was made to simulate reaction kinetics inside a thermal cracking furnace to produce ethylene from naphtha.

Sub-block (1) was to solve a set of highly non-linear simultaneous ordinary differential equations of naphtha cracking reaction. Sub-block (3) was the combination of many FORTRAN subroutine programs to compute various process parameters. Sub-block (7) was used to determine automatically initial conditions and reaction kinetic parameters. This sub-block consisted of several FORTRAN non-linear optimization programs, for user's option.

(3) Japanese Petrochemical Industry Model (63)

The combination of Sub-blocks (1) and (3) was made to simulate Japanese petrochemical industry.

Sub-block (1) was to simulate Japanese petrochemical socio-economic system with systems dynamics methodology. The sub-block was written with CSMP. Sub-block (3) was FORTRAN programs to compute interrelations among various petrochemical industries which were derivatives of ethylene.

Variables from the Japanese national economy as well as from other countries, such as foreign trade, crude oil price, etc., were exogenous to this model. Even though studies were made well before the last oil crisis, the results then predicted the slump of Japanese economy around 1975. This study also showed the high sensitivity to crude oil price and demonstrated the vulnerability of Japanese industry and hence national economy to the price.

(4) World Oil Energy Study (65)

The combination of Sub-blocks (1), (3), (4) and (5) was made to study world oil energy in relation to Japanese energy policy with many simplifying assumptions. The countries and regions involved were, Japan, the United States and European countries as oil consumers, and Saudi Arabia, Iran and Kuwait as oil producers.

Sub-block (1) was to simulate Japanese socio-energy-economic system with systems dynamic methodology. Sub-blocks (3) and (4) were FORTRAN programs to simulate crudely the national economy of the U.S., Europe and Middle-East. They were similar to econometric approach. Sub-block (4) was a FORTRAN linear programming optimization to simulate Japanese government policy on oil importing quota in every year interval. This study was an extension of the approach demonstrated with supervisory-digital-control (SDC) simulation in Reference (58).

The results indicated a tapering-off of the growth of the Japanese economy in the future. This study also indicated the necessity of cooperation of international experts in various countries for a full comprehension and utilization of factors outside the Japanese sphere but very important thereto.

(5) Other Applications

As mentioned above, the combination of Sub-blocks (1) and (5) with actual or simulated data resembles econometrics, and that of Sub-block (3) with the data resembles input/output analysis. Consequently, GIS/APSO can combine following methodologies:

(a) continuous system simulation
(b) discrete system simulation
(c) input/output analysis
(d) statistical analysis
(e) econometrics
(f) cross-impact matrix
(g) linear programming optimization
(h) non-linear optimization

6.2 Other Notable Simulation Studies

After indicating the possibilities of interfacing large scale models of various methodologies in Reference (56), the writer has advocated such necessities in Japan and the U.S. for large scale socio-energy-economic simulation studies.

6.2.1 United States

A large scale energy policy analysis project was conducted as combining a linear programming energy model (as a dynamic simulation) at Brookhaven National Laboratory, the U.S. macro-econometric model of Data Resources, Inc., and the U.S. input/output model of the University of Illinois.

The writer suggested the researchers of this study in subsequent years to link those various models, as much intact as possible, with telecommunication lines and execute them distributively. By this way, the individual models might not need to be reduced in size in order for the combined model to be executed with one computer. The writer's suggestion was also due to the fact that the credibility of each large scale model would often be lost during such reduction processes, negating previous efforts and attempts to increase the credibility with large, comprehensive and detailed models.

6.2.2 Japan

(1) Reference (45) effectively utilized policy delphi and cross-impact matrix analysis for the synthesis of "traditional" systems dynamics modeling with a time-dependent version of cross-impact analysis, the so-called Probabilistic Systems Dynamics (PSD) technique.

Referring back to Figure 8, this was the combination of Sub-blocks (1) and (6) to analyze the Japanese Sun-Shine Energy Policy. Sub-block (1) was to simulate Japanese socio-energy-economic system with systems dynamic methodology. Sub-block (6) was a kind of data base of cross-impact matrix study for probabilistic occurence of consequences with various policy decisions on alternative new energy developments, which study was made independently by delphi method prior to this simulation work.

This PSD technique enables one to model and analyze;

(a) The impact of event occurrences (via the cross-impact matrix) on relationships in the (Systems Dynamics) model.

(b) The impact of (Systems Dynamics) model variables on the event probabilities (in the cross-impact model).

Figure 4 illustrates the conceptual features of the PSD model. PSD has also been applied to model The Uruguay economy (46), and a subset of the U.S. agriculture (13). The role of computer conferencing system here rests in generating the event set and aiding in the interactive generation of the cross-impact matrices (41).

(2) A serious project is now undergoing to combine econometric model of Soka University, systems dynamics (or contrinuous) simulation model of 6 regions of the world made by Osaka University and input/output model of Tokyo University in Japan, for world mineral resource analysis (47).

(3) The work of Reference (36) should be noteworthy, since it made parallel modeling of various sectors of an urban development policy analysis, having initial, derivative and termination sections in each sector as an ordinary CSMP or CSSL model has. This simulation combined component systems dynamics models with associated data bases. The models of various sectors of Osaka-Kobe urban areas in Japan were constructed in parallel fashion with PL/1 language and executed interactively and simultaneous with a single IBM computer.

This work claims the merits of this approach as follows;

a. Comprehension of structures and mechanism of real world with systems engineering analysis.

b. Sharing of basic functional programs.

c. Stepwise construction of modular complementary models.

d. Easy analysis of model functions.

e. Easy substituitions of alternative models and methodologies.

When each model in this work will be dispersed to dissimilar computers interfaced with a value added network, the distributed computer simulation system will be realized in urban scale. Distributed computer simulation system will be able to disperse those component models to distributed dissimilar computers, which will enhance the merits mentioned above, with close cooperation of personnel engaged in the individual divisions and operations.

Other related submodels of energy use, resource allocation, national economy, foreign trade, international monetary systems, and data bases were surveyed and are available in the literature (61, 62). There are many other socio-energy-economic models of several methodologies (9, 11, 18).

7. Other Activities

(1) 1971 SCSC

As General Chairman, the writer organized a panel discussion session on macro-system simulation (42) at the 1971 Summer Computer Simulation Conference (SCSC) held in Boston, Mass.. He advocated the term "peace game" instead of "war game". It was that way of thinking that led him to the formation of GLOSAS Project (66).

(2) 1973 SCSC

As a Session Chairman, the writer organized a panel discussion session on distributed computer simulation with global computer network at the 1973 SCSC held in Montreal, Canada (9).

(3) 1974 SCSC

The writer also organized Energy Group at the 1974 SCSC held in Houston, TX, where many prominent researchers, such as Professor R. J. Deam of the Energy Research Unit of Queen Mary College in London (World Oil Model with linear programming), Dr. F. T. Sparrow of the National Science Foundation, Mr. John Stover of Future Groups (45) and others from Wharton School of Economics and TVA, etc., presented energy models of various methodologies.

VII. DELINEATION OF ANTICIPATED RESULTS

Delineation of anticipated results for the integrated, interactive peace gaming simulation, particularly on the acute global problems seen from Japanese viewpoints but certainly applicable to other countries, are the following.

1. Tug of War on Crude Oil Among Countries

Demand for oil in Japan and the United States as well as in the rest of the world will grow in the foreseeable future. Because the oil producing states are generally against increasing their oil production, the prospects for a race among countries for the available crude oil supply imminent if past patterns are adhered to.

Proposed Solution:

Conduct joint systems analysis, interactive peace gaming simulation and consultations among experts on the energy problem through the global computer conferencing system so that supply structure, demand consumption rates (depending on oil prices) may be analyzed on a long-range basis as part of a mutual policy for all countries.

2. Impossibility of Additional Refinery Installation within Japan

Additional refinery capacity is needed if Japan is to be able to meet with the increasing demand for energy, particularly of oil. However, because of pollution, peoples' opposition movements, shortage of industrial site, etc., it is not possible any longer to build that needed additional capacity in Japan.

Proposed Solution:

To meet with the growing demand for energy, Japan will have to locate additional refinery capacity in foreign countries. The interactive gaming simulation may be used to determine when those refineries should be built and what capacities they should have. In addition, it may also help optimizing foreign and domestic investment in the oil industry and establish a macro-management plan to achieve efficient distribution of energy among energy-dependent industries. Moreover, this may allow Japan to re-focus its foreign policy to achieve the necessary collaboration with other governments to build these refineries and industrial complex and to give Japan sufficient time to make financial preparations.

3. Growth Pattern of Japanese Petrochemical Industry (63)

Having been a central part of Japan's spectacular growth in the postwar era, Japanese petrochemical industry now faces problems of pollution, peoples' opposition and the lack of plant site availability. The growth pattern of the industry may be studied in relation to the expansion of its plant capacity by the use of the interactive gaming simulation.

Proposed Solution:

Conduct a study to forecast the future of this industry. As demand will exceed domestic production, Japan will have to rely upon imports to make up the difference, a situation which will involve the investment of enormous sums in foreign countries in the next five to ten years period. The study may enable policy-makers to determine appropriate investment levels in the industry, both domestically and internationally.

4. Japanese Domestic Fuel's Competition, Distribution and Environmental Problems

Development of different sources of energy (oil, coal, natural gas, nuclear) means that a method for determining appropriate distribution of energy sources among selected industries is needed.

Proposed Solution:

The interactive simulation may be able to determine the appropriate distribution among competing fuels to achieve the most efficient allocation according to the demands of industry. It may also help to locate appropriate investment in new energy research, determine which industries should be shifted to foreign sites, determine the possible growth in a specific industry, project energy consumption for each industry, and recommend steps for minimizing environmental problems.

VIII. SPIN-OFF BENEFITS

1. Distributed, Interactive Gaming Computer Simulation System

Since the need for interconnecting and running models of all kinds will become more pressing in a variety of fields, the distributed, interactive gaming computer simulation system may also be applied to the following cases:

(1) General advantages of distributed information processing capability may be listed as follows (3);

(a) Processing resources are accessible by a greater number of users more efficiently and economically.

(b) Greater on-line throughput and improved response time.

(c) Improved availability and reliability via the existence of multiple resources.

(d) More efficient utilization of processing resources through uniform load distribution.

This last point may provide a stabilization of processing resources, extending the time at which additional facilities must be added to handle increasing loads. In some cases, too, a net reduction in data communications facility costs is anticipated. Reason: a reduction in communications equipment density surrounding large centralized configurations.

(2) Corporate merger activity provides another motivation to pursue distributed information processing.

Company A, using brand X computers, purchases or acquires control of company B which uses brand Y computers. Both installations are operational, do useful work, and represent substantial system design, development, programming, implementation, and hardware facility investment.

Installation interaction is desirable, but replacement of one with a copy of the other so interaction can occur is viewed less than enthusiastically by the principles.

Considerable pressure is being applied to computer manufacturers to provide for significantly greater "peaceful coexistence" levels between different machines than are possible today.

(3) Decentralization of corporate management, especially of multi-national corporations, is also the current strong trend and will be accelerated with the spread of the global public VANs. On the other hand, the corporate management is nowadays being more assisted with management simulation models, such as marketing and financial forecasting programs, etc., which are associated with data base management systems.

Geographic considerations are frequently a major factor in deciding to distribute information processing. Corporations and other organizations with geographically separated elements may find efforts to provide all information processing from a single, centralized site difficult, due to the distances involved.

Distributed computer simulation system may be applicable to the integration of those management simulation models of decentralized corporate operations, even in international scale.

(4) Various divisions and operations of urban community, such as transportation, pollution, education, industry, economy, etc., have been simulated separately.

Those individual simulation models may also be integrated with the use of the distributed computer simulation system, which will enhance close cooperation of personnel engaged in the individual divisions and operations.

(5) Similar to the above, state-wide individual energy models may also be integrated with the federal level energy models with the use of the distributed computer simulation system. Interactive gaming approach may also be useful for the analysis of inter-state energy movements (75).

Donovan of MIT (14) once integrated several energy data bases programmed with different languages for various municipal divisions of Boston, and executed the data base integrated on an IBM computer.

(6) Along with the decentralization of corporate management, the establishment of distributed data base management system is also in the current trend. Applications are for federal, state and municipal governments, multi-national corporations and organizations, etc..

The state-of-the-art of the system at the present is, however, mainly with single type, distributed computers and with the use of a single programming language.

Distributed computer simulation system may lead the art to the way of utilizing multiple distributed, dissimilar computers with the data bases programmed in various languages.

(7) Applications of distributed computer simulation system to engineering subjects will be numerous.

To name but a few as for examples, chemical or nuclear reaction kinetics simulation models may be coupled with process control dynamic simulation programs. The supervisory control programs may then be interfaced with corporate management forecasting programs.

(8) Distributed computer simulation technology may also lead to effective utilization of mini-computers around a distributed computer network, in which computer-specialized software will be resided.

(9) Possible extension of the distributed computer simulation technology is to include various programming languages, such as BASIC, PL/1, ALGOL, APL, etc..

(10) Consolidation and conservation of computer (hardware and software), man-power, financial resources with reduction of their duplications may also be brought with the applications of the distributed computer processing and simulation technology.

2. GLOSAS Project

The following is a list of some important secondary effects which may be driven from GLOSAS Project.

(1) Promotion of Mutual Understanding and Expertise

As the task of solving various global problems will be jointly undertaken by experts from the participating states, the project will not only advance technology, but will also lead to mutual understanding, raise expertise and enhance the global perspective.

(2) Improvements in Computer Simulation Technology

Since a large number of experts will be responsible for the computer simulation, model building, and systems analysis of each sector, the performance capability of each model will be increased and the efficient utilization of techniques and resources (hardware and software) will be promoted. This project will also result in the construction of models of increased reliability.

(3) Cost Savings through Joint Coordination

Since the project is international in scope, substantial savings result from reduced development costs can be obtained by avoiding the duplication of projects through the joint development of the technologies. Such joint coordination is also realistic and will lead to greater international cooperation.

(4) Improvements in Computer and Telecommunication Technologies

As a result of this project, computer and telecommunication hardware capabilities may also be greatly enhanced in the following areas;

(a) Computer simulation techniques needed in management and government.

(b) Development of software in support of computer simulation.

(c) Development of hardware in support of interactive simulation.

(d) Global computer network.

(e) Dissemination of computer conferencing technology.

(f) Promotion of global satellite telecommunication technology.

(5) Application to Education

The interactive global gaming simulation system to be developed by this project may be used for personnel training and education in international affairs and economics, political science, social and industrial management, environmental and ecology studies, energy, food and resource uses, etc..

Also, integrated use of global computer network coupled with computer conferencing system may provide international extension courses of various curricula being taught at various universities throughout the world. Namely, video tapes of the courses may be leased to students for their viewing with their home TV sets. Quiz, homework, term paper and exams may be exchanged through the combined use of the home TV, phone coupler, terminal, and telephone with the computer conferencing system on the global network. Even the computer assisted instruction in university computers may be used by students in various countries.

Side benefits of this interconnections among computers of educational facilities in various countries is to provide less expensive computing cost in the United States to other countries' universities. This cost differentials will be predominantly advantageous to participants of global computer network, due solely to the time differences between the United States and most countries in overseas.

(6) Dissemination of Important Software, Data and Information

Currently in the United States, important software, data bases and information in economy, science, engineering, medicine, agriculture, biology, environment, etc. are being consolidated into various computer networks. With the use of global computer network coupled with computer conferencing system, they can be disseminated in other countries, thereby promoting cultural exchange and improving standards of industry, economy and livings in various countries outside the United States.

IX. ANTICIPATED USERS OF GLOBAL "PEACE" GAMING SIMULATION STUDIES

Possible users of interactive "peace" gaming simulation studies to be developed by this GLOSAS Project on multi-national policy analysis of various global problems can be listed as follows;

(1) International:

United Nations
UNESCO
United Nations University
OECD
International Monetary Fund (IMF)
World Bank
International Energy Administration
etc.

(2) National:

National and state governmental agencies
Research institutes
Corporations
News media
Universities
Professional associations
etc.

X. CONCLUSION

The global problems facing the world now necessitate the extension of their geographic and disciplinary boundaries to include the close interactions of foreign trade, national resources allocations, and even political-international relationships.

Computer simulation of various subjects on a worldwide scale is an unavoidable necessity now and in the future. Such large scale computer simulation cannot be realized unless it utilizes multiple computers linked with a computer communication network, and unless multiple working teams scattered around the world will exchange their know-how and data resources through the computer conferencing system. Different parties should construct and study simulation models of their regions. Such models should be tied together by means of distributed computer simulation system to study their interactions and influences on a truly global scale.

The distributed computer simulation system (DCSS) will enable to interface component models written in various simulation languages, which models will be resided 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 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 corporate management, socio-energy-economies, etc.. The extent of the public VAN in global scale will also make it possible to apply such gaming simulation to the analysis of multi-national corporation and international economy.

By using the computer conferencing system, there will also be created a "Global Invisible Research Institute", which will gather together experts from all parts of the world at their convenience and availability for the integrated use of their "brainware" for the betterment 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 economically, technically, and practically possible. It is also most important and timely. What is urgent now is to establish suitable ground rules, reasonable assumptions and a common set of premises for the various modellers to work from. Such team-work of computer simulationists with global computer network will also promote the peaceful collaboration among nations.

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 (42), and the potential good therefrom by peoples of the world.

The anticipated spin-off benefits out of this GLOSAS Project on the energy, food and other global policy analysis and evaluation in global scale, with the comprehensive uses of the most advanced computer conferencing, simulation and network technologies will be many folds, in education, medicine, agriculture, science and technology, economics, etc., to name but a few and 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.

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