GRAPHIC LANGUAGES FOR POLICY MODELS: DIAGRAMMING GLOBAL MODEL STRUCTURES

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ABSTRACT

Planning for the future in regional or global terms involves issues of extraordinary complexity. Computers play a vital role in managing the intricacies of large-scale situations through simulation models. Computer graphics systems could play a significant role as well.

Basic characeristics of the modelling environment, however, create a number of communication problems. Typically cited are communications between model builders and model users. An interdisciplinary research team is developing visual means, namely diagrams, for presenting the architectronics of the models to enable effective cross-professional dialogue.

Many of the issues raised relate to effectively communicating complex information.

RÉSUMÉ

La planification de l'avenir à l'échelle régionale ou mondiale porte sur les questions d'une extraordinaire complexité. L'ordinateur joue un rôle essentiel dans la gestion des écheveaux de situations à grande échelle, en permettant l'exécution de modèles de simulation. L'infographie peut jouer un rôle tout aussi important.

Les caractéristiques fondamentales des conditions de la modélisation créent cependant bon nombre de problèmes de communication, typiquement entre les constructeurs et les utilisateurs des modèles. Aussi une équipe de recherches multidisciplinaires est en train de développer des moyens de schématisation qui permettront de présenter l'architecture électronique des modèles afin de faciliter le dialogue efficace entre professionnels.

Bon nombre des questions soulevées sont liées à la communication efficace d'informations complexes.

A research group studying computer-based global simulation models is creating diagrams of these models' structure as a basis for an explanation of an individual model and the comparison of several models.[1] The mechanisms of the models are too complex to be verbally (symbolically) outlined and compared by the users or even the modellers themselves. A diagrammatic summary of each of the complex models would give users a construct in which to address issues of content, accuracy, methodology, and validity. As interest in displaying information increases, so does the importance of understanding the elements involved in constructing successful communication. This essay describes how a graphic language was developed that enables a complex system to be effectively communicated to a broad audience.

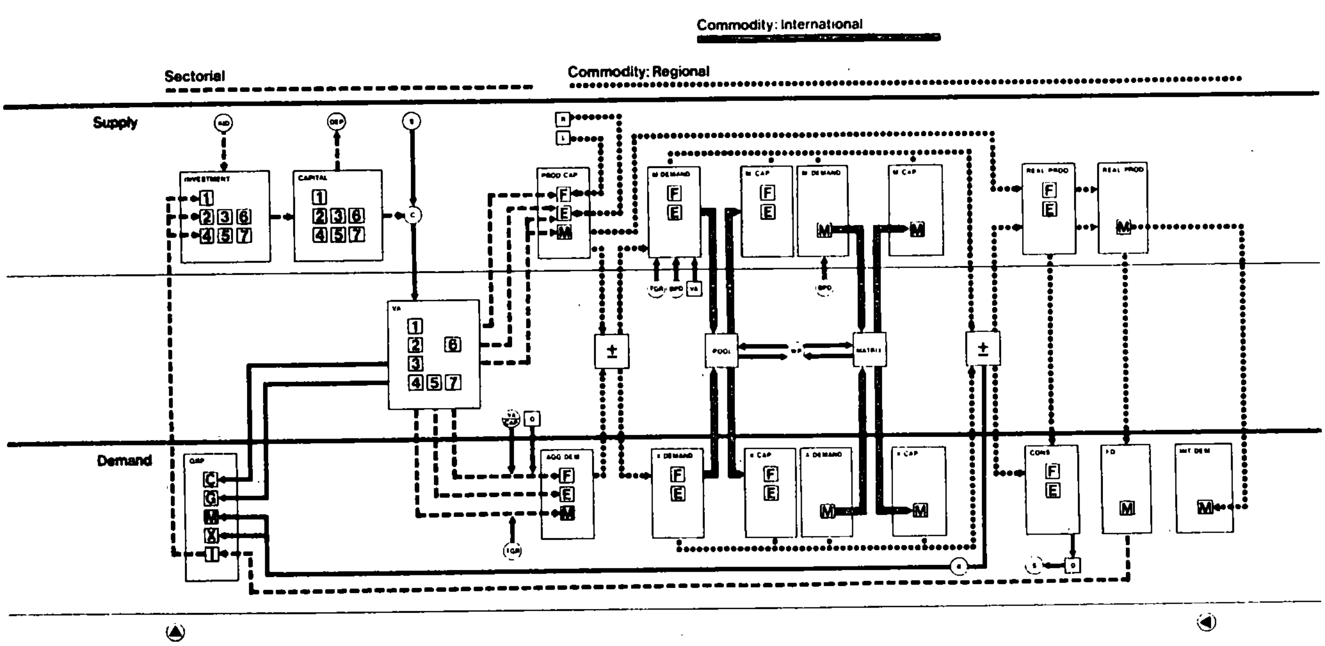
A case study in diagramming

Three years ago, an interdisciplinary, international research team[2] sponsored by the East-West Center in Honolulu began a study of long-range planning and the analysis of global problems. The research team, consisting of a mathematician (Berrien Moore III), two computer scientists, and three policy makers investigated a recent innovation in the technology of analyzing regional and global problems — namely computer-based global modelling — and its potential contribution to policy analysis in issues of development. A graphic designer (Susan Marcus) joined the group to help build the diagrams. A grant from the National Endowment for the Arts (USA) acknowledges and extends support to this unusual collaboration.

Global models and the policy context

A model is a reduced description of reality.[3] The purpose of modelling is to describe behavior in a way that makes relationships and interactions clear. Computer-based models are sets of equations defining certain relationships among the most important governing variables describing a system's behavior. A representation of the world that integrates the issues confronting the policy maker is fundamental to the construction of models that can be incorporated into a policy context. Global simulation models are in an early stage of development. As with any other technology, the models' limitations as well as their abilities must be better understood before they can be incorporated into the policy

Figure 1. Prototypical Global Model diagram © East-West Center.



context for which they were intended.

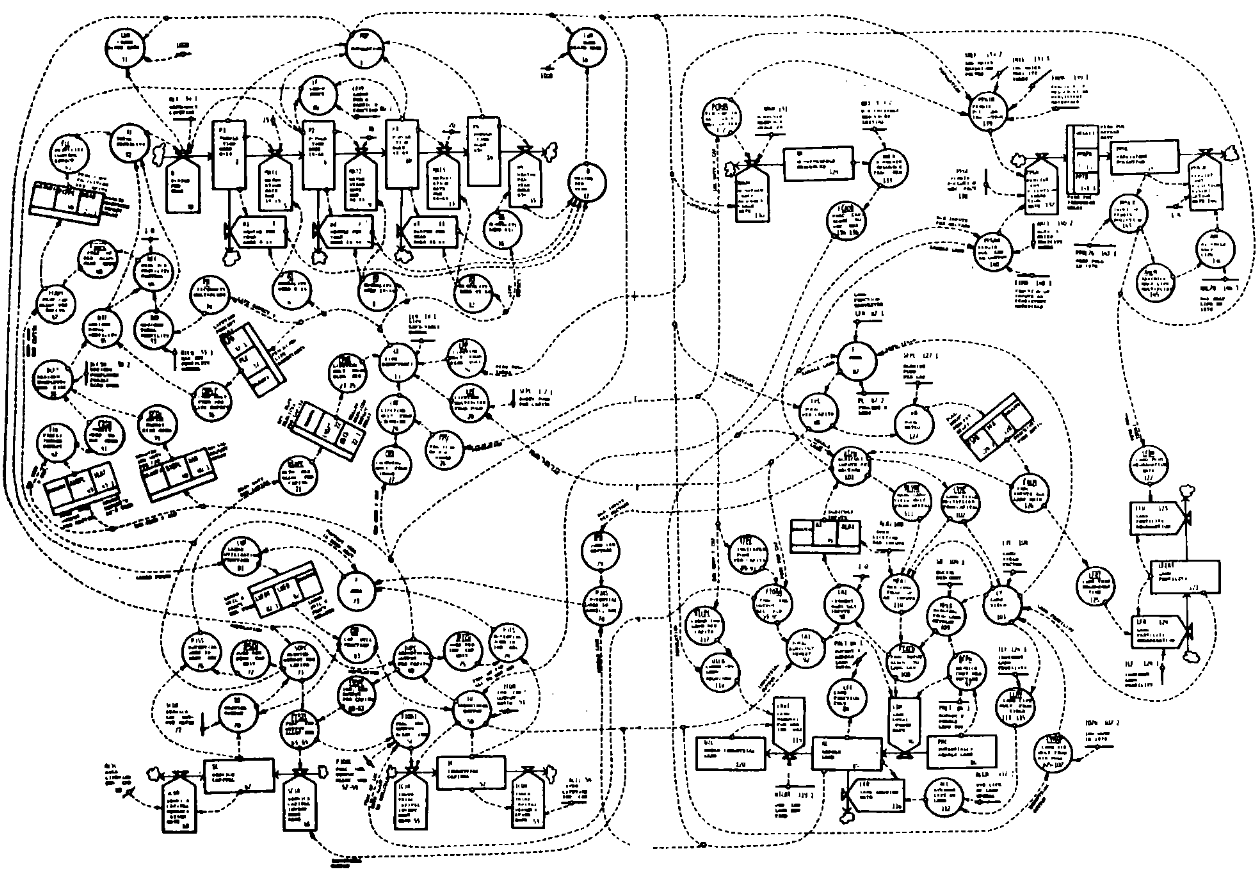
For each model, the basic structure is drawn as a flow chart of the causalities distinguishing inter-regional relations from intra-regional ones and physical from financial structure (Figure 1). In the absence of sufficient program documentation, the diagrams and the process of creating them became a critically important tool for understanding the models.

While the documentation prepared by modelling teams sometimes includes flow charts of the computer functions and their related paradigms, these charts are not translated into the language spoken in the policy making environment. For instance, the diagram in Figure 2 is based on electrical engineering symbols.

Most computer-supported economic planning models in use today have short time horizons, focus strictly on national dynamics, and rely heavily on empirical data. The assumptions and paradigms used in constructing these models differ dramatically from those used in creating global models. To date, the design of global models has been the prerogative of engineers, mathematicians, and systems analysts without the collaboration of policy makers or political scientists. Typically, therefore, the communication between the model builder and the model user is inadequate. These communcation shortcomings are barriers to the successful integration of global models into the decision-making forums.[4]

Global models are still relatively inaccessible to many potential users, and most policy makers are generally ignorant of the possibilities global models offer them. In spite of an increase in publications and model demonstrations, the entire process of making computer models accessible to a policy maker is undeveloped.[5] How can users quickly, yet accurately and thoroughly, evaluate the efficacy of the complex models created, ostensibly for their use, by other professionals? Despite the considerable progress in developing natural language programs, sophisticated programs (often written in FORTRAN) generally remain inaccessible to the decision maker. In the same vein, the computer's output must be made more comprehensible to the

Figure 2. An early global model flow chart using electrical engineering symbols.



policy maker if global models are to become useful policy tools. A printout twenty centimeters thick composed of complex plots and incomprehensible tables hardly speaks the decision maker's language. Putting the same information in the same format on a CRT does not help. A visual vocabulary for a model's internal structure and output is needed. We are experimenting with the development of a graphic, diagrammatic means for translating the complexities of the global models' structures into carefully constructed visual forms, giving a broad audience access to the conceptual framework upon which this tool is based.

Transparency

The mystique of the "black box" inside of which the model builder performs "magic" works against the evolution of a successful tool. The model builder's confidence in the output presently derived in secretive ways will not be transferred to the model user until the builder can:
1. depict the conceptual structure of the model,
2. describe the quality of use of data, and
3. provide output that relates to the user's needs.

Each of these communication tasks is facilitated by visualization. Each could contribute to the model's transparency by being "on-line", i.e., part of the model's actual workings. Our diagrams address the first communication requirement, using a visual language that is sufficiently general to address several professions.

The mechanisms of global scale simulation models are multi-dimensional and complex. The world system they define is interdependent and counter-intuitive. A straightforward map of the model's conceptual framework enables a model user to examine any model, to compare its world view with his own or another model's.

The diagrams for the global model study have another quality that is invisible. These diagrams represent a collaboration between scientists and a graphic designer. When diagram notations are tools for thinking, for problem definitions and solving, the process of creating them is as important as the product.

Figure 3. London Underground Map

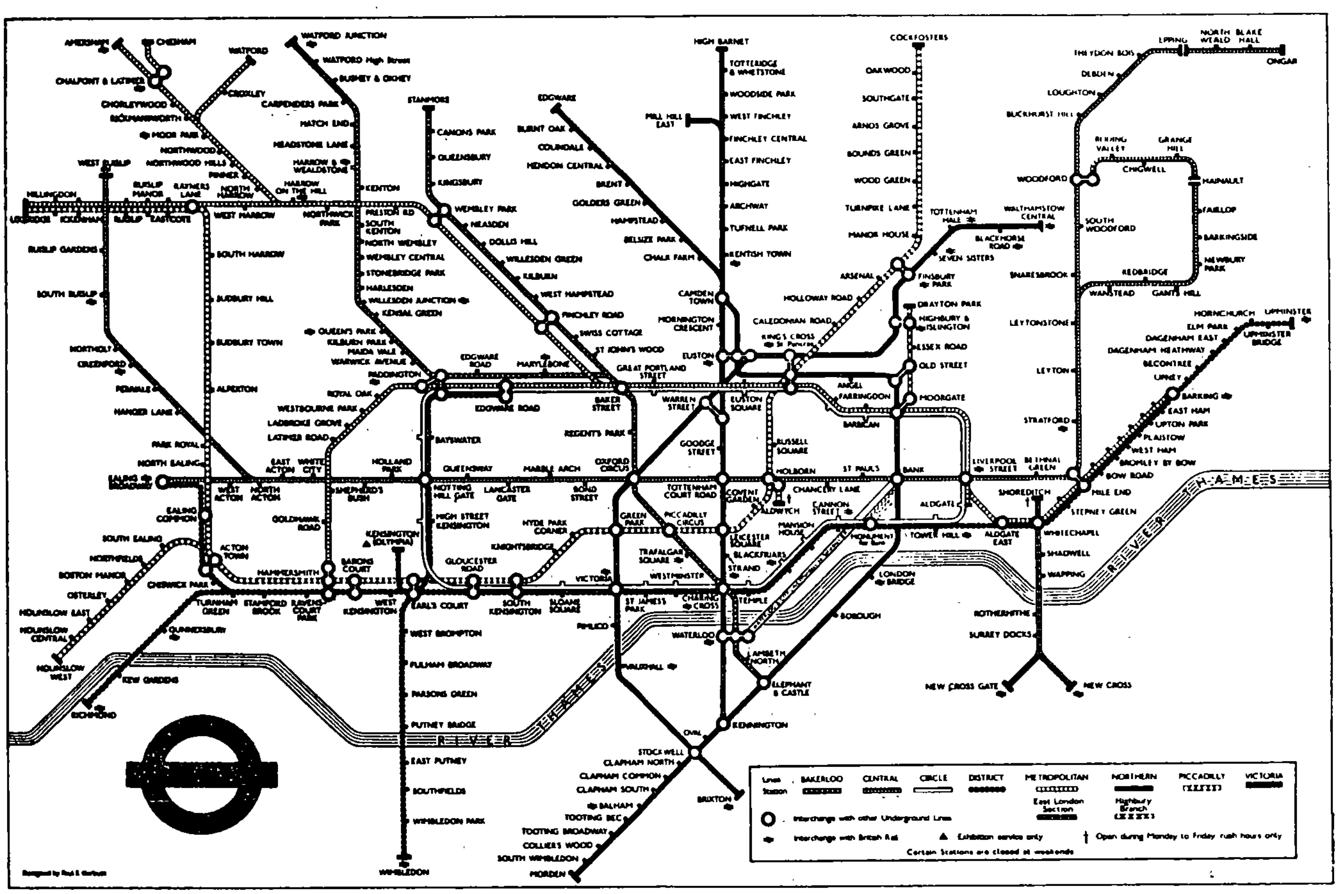
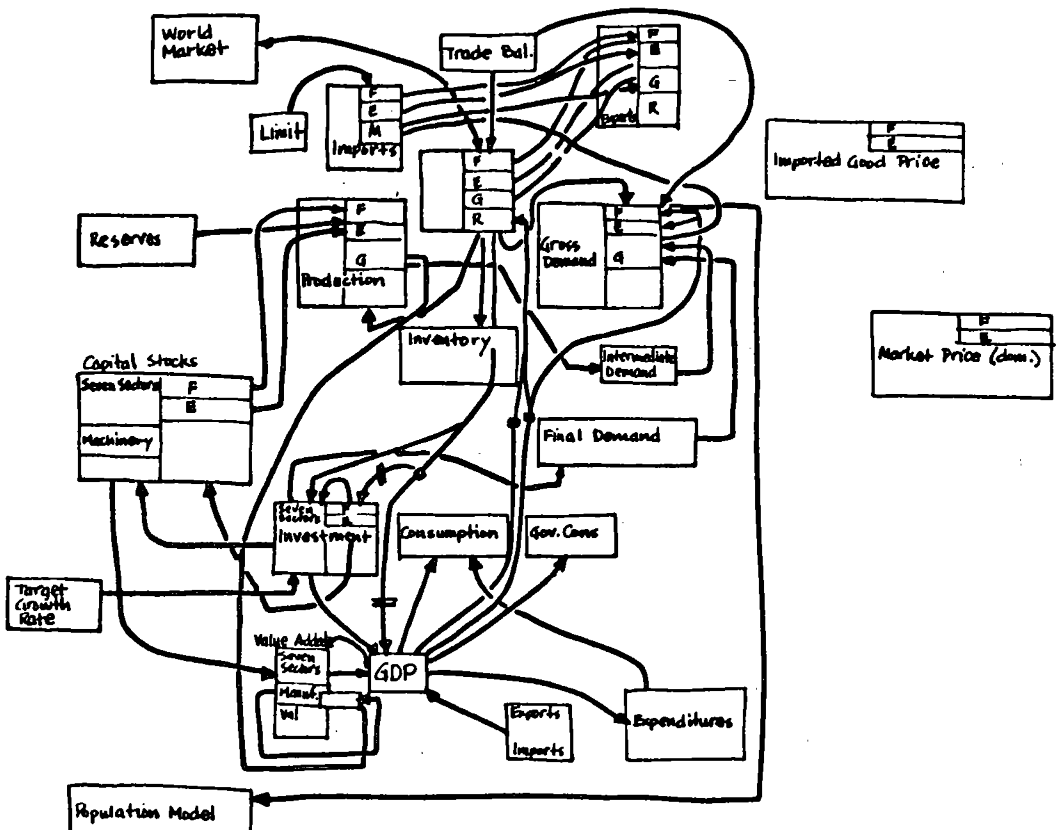


Figure 3 shows a portion of a model's structure at an early stage in the evolution of this diagramming project. Affectionately called a spaghetti diagram by the people who make it and less affectionately by the people who attempt to use it, this diagram represents a computer scientist's initial attempt at visualising the structure of a portion of one of the models investigated by the East-West Center research team.

By generating several possible grids and linkages, alternative hierarchies in terms of visual elements and the model structure took shape. A language system evolved that enabled the model's complexities to be clarified. The current prototype seen in Figure 1 condenses three plates of spaghetti into one digestible form. The structure of the model's network of information is visible. By applying the same principles to the other global models, a standardized format emerges that allows a user to compare the models' conceptual structures just as they enable the research team itself to grasp these complex systems.

Figure 4. Early diagram of a model © East-West Center.



Although the diagrams created within this project are all hand made, a computer graphics system intended for diagram construction would have facilitated diagram building.

Graphic principles

Understanding the elements involved in designing successful communication is imperative. There is no theory-based set of design principles that eliminates all "bad" imagery.[6] However, graphic designers accustomed to handling complex scientific and technical information in a systematic and structural way offer a resource for the development of more effective presentations of computer-generated material.

By using graphic design as a window, it is possible to identify perceptual elements involved and to discuss some principles of "good fit" between physical form and the content/context of the information to be visualized.[7]

The diagram of the London Underground (Figure 4) is a map of a complex physical space abstracted from reality. Although the time and distance between subway stops is not measurable, a user easily can find the most efficient route between locations. The success of this heuristic diagram derives from its clear hierarchies and a minimal number of visual elements: colored lines (the grid, the Thames, and the subway lines), a language of symbols (circles, ticks on the line), and a typographic hierarchy (the title, the key, the names of the stops). Spatial locations, differentiations of color and texture, and hierarchies of size form the basic vocabulary of perceivable code pertaining to visual structures. Though there are many ways of putting these elements into use, the number of elements themselves is limited. Each of these elements can be built into computer graphics software.

Spatial location is one element of a visual perceptual code. Linkages and hierarchies are subsets of this category. The progression in complexity from a plane to a line to a point is a visual hierarchy. A graphic designer speaks of a grid, the spatial organization that facilitates a structured combination of the content. A grid is a tool for quick solutions and for consistency. Distinction of color and pattern are other perceivable codes. The human eye is capable of differentiating numerous gradations of color and texture, but only a few distinguishable and memorable ones should be combined within any single diagram. Colors include black, white, and shades of grey. Lines, symbols, and typography are patterns and textures. If the medium in which diagrams appear is not static, movement and time can be depicted. In a stationary medium, however, time can be a component of spatial location.

Summary

Visualizing the structure and process of global models enhances the analysis of and use of these models. The process of creating the diagrams required the collaboration of an information-oriented graphic designer and various scientists. It is now possible to adapt the diagrams for display on computer graphics systems and to test their efficacy as a conceptual and a perceptual interace between the model and a viewer of the model.

Footnotes/References

[1]The three simulation models of global dynamics reviewed were: the Mesarovic-Pestel World Integrated Model (WIM), Japan's FUGI model, and the SARU model from the United Kingdom's Department of Environment.

These models fit the research team's definition of a world model: they are global in scope, and they carry their calculations beyond ten years. They represent the most advanced products of this young technology. Each was developed expressly as a tool for policy analysis.

[2]The team consisted of Dr. Berrien Moore III, Associate Professor of Mathematics, University of New Hampshire (project coordinator); Dr. Ada Demb, Research Scholar, International Institute for Applied Systems Analysis, Vienna, Austria; Dr. Hisashi Ishitani, Associate Professor, Institute of Science and Aeronautical Science, University of Tokyo, Japan; N.R. Miller, First Assistant Commissioner, Industries Assistance Commission, Canberra, Australia; Budi Sudarsono, Senior Staff Member, National Atomic Energy Agency, Jakarta, Indonesia; and Professor G.A. Vignaux, Department of Information Science, Victoria University, Wellington, New Zealand. After the initial term of the research, Susan Marcus, graphic designer, Meta-Graphics, Berkeley, California, joined the group.

[3]Mesarovic, M. and Pestel, E. Mankind and the Turning Point. New York: Dutton, 1974.

[4]Richardson, John M., Jr. "Global modelling," Futures 10:6 (1978).

[5]Fitter, M., and Green, T.R.G. "When do diagrams make good computer languages," International Journal of Man-Machine Studies 11:235-261 (1979).

[6]Marcus, Aaron. "Computer-assisted chart making from the graphic designer's perspective," Computer Graphics 14:3, July 1980, 247-253.

[7]Alexander, C. Notes on the Synthesis of Form. Cambridge, Massachusetts: Harvard University Press, 1964.