This paper describes a proposal to use an implementation of client-server technology on the Internet for simulating a number of aspects of electric power production, distribution, and consumption within a wholly new regulatory, financing, operating, and control environment. This approach would use a large number of people to generate strategies and decisions, in a real-time context, needed to drive the simulation. A World Wide Web server would provide background information about the simulation for those who chose to participate as actors in one of supported roles. Roles would be based on activities associated with different business areas and would include utility manager, independent power producer (entrepreneur), electric power futures trader, electric power futures investor, electric power wheeler, industrial customer, commercial customer, and residential customer. The simulation program would run on a system of high-performance computers (parallel computer system) that communicate between each other on a high speed communications bus. These computers would also be the server systems for the client programs used by the actors. People who want to be actors would be required to register before being given a client program, as a way to have some control over the simulation results. Each role will have its corresponding client program with graphical user interface. Each client program will support a common view of the simulation results and a role...
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specific view.

INTRODUCTION

Many big issues currently confront the utilities, regulators, financial investors, manufacturing managers, and homeowners with the regard to the future production, distribution, access to and use of electric power. These issues include

- Power generating schedules
- Variable pricing of power
- Reliability and quality of power
- Integration of digital processor chips with power meters
- Expanded use of power electronics technology
- Use of digital processor chips for control of appliances

Changes associated with these issues are likely to occur within a common time frame which may be only months away.

Until now electric power generation has been managed by a relatively small number of utilities that have coordinated their activities, buying and selling power to each other as needed to provide continuous, uninterrupted power to industrial and residential users. When very large generating stations must be taken off line for maintenance or modification, a utility can plan down time and use reserve capacity or purchase power from a neighboring utility to cover the loss from the plant that is off-line. If independent power producers are brought into the picture, scheduling the production and distribution of power becomes more complicated. The added complications are not too bad if the amount of additional power provided by the independents is small compared to the base load required. But when it becomes significant relative to base load, the utilities have a much tougher job. If what the independents supply becomes large enough, the demands on the utilities could out-strip their capabilities to manage service reliably.

Large amounts of power generated by independent producers will alter pricing structures and arrangements in ways that are hard to anticipate at this time. Identifying potential impacts is much easier than second guessing how large or small these impacts might be.

Greater use of modern power electronics technology by large industrial users can help them solve many problems they have, but can create new problems for residential and small business customers such as greater line noise (voltage spikes) that degrades the quality of power. Who pays for fixing problems when quality deteriorates? The customer who adds noise or the customer whose quality requirements are stricter?

Will pricing incentives encourage residential customers to alter their patterns
of power use, e.g. turning off large power consuming appliances during peak power demand hours of the day? How will variable price information be provided to customers who may want to lower their power bills? How frequently will prices change? What will be in impact of the independent power producers on price arrangements? Will customers be able to select among power producers the way they now do for long distance telephone service?

What will be the impact of establishing an electric power futures market? What additional standards will have to be developed to maintain high reliability and quality of power? Will all these changes really lower the cost of electric power or cause it to increase?

Tools are needed to help get answers to the questions posed above. Computers and simulation models are often used to study the behavior of complex systems which must operate under a variety of different conditions and for which some of the possible system behaviors are poorly understood. This approach is especially useful when construction and operation of a prototype is very expensive or where operation may pose great risks to life until certain phenomena or possible behaviors are better understood.

Utilities currently make heavy use of computers and simulation models to assist with a wide range of planning, system design, and project management activities. Current analysis and planning software do not take into account big changes coming soon as result of changes in regulatory policy. New power production alternatives and more options in arrangements for its delivery to end-users will likely change the whole way of doing business. New strategies for generating, distributing, and using power will be available. Many more different types of decisions will be made by consumers, investors, power producers, and distributors than has been the case until now. A difficult part of any study using simulation methods to understand complex system behaviors, especially in real-time application areas that depend heavily on decisions people make, is to get realistic decision sequences.

One way to get an idea of what life might be like with many large changes occurring at the same time is to use computers to simulate the behavior of each component of the complex system and allow a large number of people to participate as actors to work within a framework of rules to generate strategies and make decisions based on the current state of the simulation results. The simulation would present a real-time context to each actor. In the past an effort of this type would be done on a large central supercomputer. Current and future computer, network, and telecommunications technologies permit use of new ways to study complex systems. Rather than running large simulations on a single big machine, they can be distributed over many computers spread over a wide geographic area. Expensive simulation facilities are resources that can now be more widely shared. More people can be given access to these resources and can participate in studies from their own
Though network technology is available to permit use of this new approach to simulation, much development will be required to design and implement the environment needed to do simulations in this manner. This additional development will present technical challenges that are significant and of interest in their own right, apart from the complex electric power system behaviors that will be studied as one area of application of this approach. Once networked computing capabilities exist to do the type of simulations preposed here, they should be available for use in other application areas such as health care delivery, transportation (e.g., Intelligent Vehicle Highway System), and various types of automated manufacturing systems (e.g., "just-in-time" manufacturing systems).

With appropriate planning and design of interfaces, complex systems could be built from a variety of components which could themselves be run, stand-alone, for specialized studies, again involving a number of participants spread over a large geographical area.

Ideas for the approach to simulation proposed here have been stimulated by several current uses of the Internet. One is the Multi-User Dungeon (MUD) games operated on the Internet and played primarily by college and university students, sometimes for hours to days at a stretch. Another is the simulated missions to the outer planets organized and operated for students in grades 8-12 as part of an effort to introduce these students to some of the ways computer networks can be used to support large geographically distributed projects like those NASA undertakes.

PROPOSAL

The proposal is as follows:

1. Use a client-server architecture for developing a simulation program to run on high-speed (server) computers that communicate among themselves on a high speed bus, with actor access using clients on the Internet.

2. Use a World Wide Web server to provide background information about the simulation and to manage actor registration, client software distribution arrangements, and other communications needed to manage the simulation environment.

3. Use multicast backbone (MBONE) capabilities to provide support for broadcasting large volumes of real-time information used in common (such as graphical interface displays) which must be viewed by all actors.
4. Invite people who are interested in being actors to register for a role before providing them with the client software they need. By enlisting a large number of people across the nation to participate in such a simulation, it is possible to get a range of decisions and strategies to drive the simulation.

5. At least two graphical displays will be required for each role: one a common view shared by all actors and the other a view specific to the role itself. Additional role-specific views may be required in some cases. Commercial data acquisition system software such as LabView could be integrated into the simulation environment to give it a more realistic look and feel. Commercial software used in other business areas could likewise be integrated, as appropriate, into the simulation environment.

SUGGESTIONS FOR IMPLEMENTATION

1. Each role will have a particular client associated with it. After registering for a particular role using a Web browser, the browser will then download the requested client and add it to the existing collection of viewers associated with the Web browser. Once the client is launched, it then is used as an independent client, with its own communication port, to operate with its corresponding server.

2. Consider use of Mbone simulcast techniques to broadcast the common view (and perhaps all views) if the number of players or the frequency of display updates becomes too large.

3. The clients would have to include capabilities for data validation, input data range checking, and other tests to be sure the players understand the rules and play within their framework. Efforts need to be made to discourage frivolous play.

4. Some roles may be simpler than others. Some of the independent power producers may set up a turbine generator at the head of a natural gas well and let it run, generating power at a constant rate for many months. For cases such as this, pools or associations can be formed to add complexity and interest value to the independent power producer role. Likewise a residential consumer may decide to set up operating profiles for major appliances and not change them for long periods. In this case the homeowner role player may be interested in trying as many as a dozen variations of a basic strategy in order to make some comparisons. This kind of an approach should be encouraged as a way for players to gain a better understanding of the system dynamics at work.

5. Get help from the designers of SimCity and Lunicus (popular games developed for desk top computers) to assist with designing and developing
graphical user interfaces that will appeal to the audience from whom the actors will come.

6. Early prototypes to test the usefulness of this approach to simulation could be based on a current utility such as TVA or on a regional power pool where the power generation and consumption patterns are well understood.

7. Goals will have to be defined for each role; rewards will have to be provided. Winners perhaps will need to be recognized by the actor community.

8. Simulation models could in principle be provided by any participant. Model selection and simulation configuration would have to be controlled by a Master Director or Coordinator.

9. Initial implementation would likely have to focus heavily on networking and telecommunications interface issues. On the simulation model side, attention would have to be given to decision support tools (since using human decision information is a major feature of this approach to simulation) and displays and to a careful consideration of how to instrument the simulation in order to get an accurate picture of the system behaviors of interest in a study and to identify what status information will be most useful for the actors. Model complexity issues would have to be deferred to a later stage.

ADVANCED TECHNOLOGY PROGRAM CONSIDERATIONS

Potential Economic Benefit

Were the proposal to be successful, the capabilities developed could help to bring about faster public acceptance of new technologies, a more informed public discussion of proposed changes to public policy, new ways to conduct marketing studies, perhaps ways to evaluate some of the impacts and economic consequences that would result if high reliability and quality of electric power is not maintained. Results of this work might suggest ways companies could use network-based, multi-user simulations to make better informed business decisions.

What is learned from completing this proposed project could also feed useful experience with complex decision making into the (mostly academic) discussion on some aspects of "electronic democracy," e.g., consequences of changes to regulatory policies.

Good Technical Ideas
What improvements to the country could occur as result of successful experience with this new approach to simulation? New capabilities for simulating other complex systems would be available for areas such as health care delivery, transportation, and manufacturing.

Strong Industry Commitment

What alliances or relationships would be required or desired? How much industry interest and support could be expected? The simulation approach proposed here is so new there is no experience base yet to suggest an answer to these questions.

Use of ATP Funds to Make a Difference

Why should Federal funding be used? The proposed approach provides a way to get experience with many new issues simultaneously in a virtual world. The virtual world can be made to look like the real world to find out how people would most likely use real world resources to accomplish their goals without the risks of failure or of failing to recognize a system behavior that could lead to undesirable consequences. New client-server capabilities would have to be developed to support the simulation approach. New types of computer and telecommunications interfaces would have to be developed that would have other uses. A general capability and new methods of studying certain types of complex systems would be made available for many other applications, much as the National Center for Supercomputing Applications (NCSA) Mosaic has done to stimulate greater use of the World Wide Web and to bring multimedia information to the public rapidly and on a large scale.

OBSERVATIONS AND COMMENTS

1. Application of the simulation approach outlined here to understanding issues associated with future electric power production and use should be a very good way to see what its value is. If it proves to be very useful, it could provide very good guidance for applying it to other areas in which real-time system behavior is difficult to understand and where human decision input significantly affects or determines what the system does.

2. The intended audience could cover a broad spectrum. Obvious potential users include utilities, state and federal regulators, power brokers, environmental groups, commercial and residential consumers, and market analysts.
3. Were this approach to simulation to be successful and stimulate wide interest and participation among high school and college students, parents of these students would likely learn about it and in many cases also be drawn in since they would have access through On-Line America, Prodigy, CompuServe and other services providing access to the Internet. In this way the public could well be drawn in to the discussion about what policies and regulations would best serve the public interest. Success with this particular project might suggest other subject areas worth applying these techniques to in order to help the public better understand the complex issues, for example, with health care delivery. Many other such simulations (e.g., Intelligent Vehicle Highway System operation) could be carried out simultaneously using the Internet technologies to allow broad access and participation.

4. If this approach were to prove useful, the implementation could be moved from the Internet to the communications system that would be actually used by the utilities and others for operating the real system of generator plants, transmission systems, etc. This would permit checking out many aspects of the operation of the real implementation before it goes into actual use.

END OF TEXT

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Dear NIST Staff,

I am submitting the following white paper for consideration to be presented at the workshop on "Information and Telecommunications Technology for the U.S. Utilities Industry Focussed Program Development" to be held in Atlanta on 30-31 January 1995.

I realize this is being submitted a week past the deadline, but I did not find out about the workshop in time to gather some of the information needed to attempt to give this paper a focus appropriate for the workshop. I am having to do most of the preparation on my own time. I did not get the announcement of the workshop until 19 Dec 1994, the day before I started my vacation for the Christmas holidays. I wrote what I could over the holidays, then had to get more information when I came back to work this month to decide whether I had enough to have material appropriate for the workshop. As you will see, what is proposed here pushes at the boundaries of the way people now use the NII and do system simulation modeling.

Please confirm as soon as possible whether this paper has any chance of consideration for presentation at the workshop. Please also let me know if there is something further I need to (could) do with this paper with respect to the Advanced Technology Program at NIST.

Thank you for your consideration,
John K. Munro Jr.

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PROGRAM IDEA

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TITLE: USE OF THE NII TO STUDY IMPACTS OF NEW TECHNOLOGIES AND POLICIES ON SUPPLY AND DEMAND OF ELECTRIC POWER.

SUBMITTING ORGANIZATION: Instrumentation and Controls Division
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