ARTIFICIAL SOCIETIES:
A CONCEPT FOR BASIC RESEARCH ON
THE SOCIETAL IMPACTS OF INFORMATION TECHNOLOGY

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The authors argue that the most important policymaking over the next several decades will occur at the intersections of the information technologies and social change. Policies to control and exploit the effects of the information technologies upon societies will be highly sought; but the understanding of those effects upon different cultures and social structures will probably be less than necessary or desired for sound policymaking. The authors propose a long-term scheme for basic research into the effects of information technology upon different societies by means of artificial societies created in a computer laboratory. The study of such artificial societies under different information overlays could provide the basis for theory development and a body of research to inform policymaking in the future.

1The concept advanced here is derived from exploratory research conducted under a grant to RAND from Richard S. Leghorn.
I. THE NEXUS OF FUTURE POLICYMAKING

The world now taking shape is not only new but new in entirely new ways. Something is happening to the nation-state itself. Governments everywhere, irrespective of ideology, appear inadequate to the new challenges....

The information revolution, so perpectively anticipated by Marshall McLuhan and widely heralded throughout the 1980s, now appears to be entering its flood tide. The astonishing political events of 1989 in Europe and China bear many marks of the information age—of a fundamental shift in political power which has been facilitated, if not instigated, by the effects of information technologies on closed societies. Perhaps less dramatically, but even more importantly in the transformation of power on a global scale, the information technologies have been steadily knitting together the world's markets and commerce for several decades.

If the historical patterns hold, the rate of impacts of the information technologies upon the most developed world societies should be cresting in the decades bracketing the turn of the century. For the foreseeable future, out to the edge of most planning horizons, nothing appears to be changing the world more rapidly than the developments in, and the exploitation of, the information technologies— even the much-

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2For an interpretation of the European political events of 1989, see Builder and Bankes, The Etiology of European Change, RAND, P-7693, December 1990.
3This is the prediction of Builder in Patterns in American Intellectual Frontiers, RAND, N-2917-A, August 1990. He argues that the American society has been following a cycle of long (Kondratieff) waves in its successive devotions to industry, technology, and now information as the dominant ideas in its development. According to these patterns, the information technologies have dominated the evolution of developed Western societies since the mid-1970s. These effects should peak around the turn of the century and then yield to the next wave several decades later.
4As used here, the term, information technologies, is taken to encompass all means involved in the acquisition, processing, and communication of information in electronic forms.
lamented demographic or ecological trends are not changing the world more rapidly or profoundly.

Shocking or subtle, the role of information technology in these changes has, so far, been more incremental and serendipitous than precipitous or deliberate. The Western television programming that had such an impact upon East European audiences had been slowly developing and expanding to meet the needs of free societies, not to propagandize their neighboring captive societies. The worldwide spread of facsimile machines was driven by the documentation needs of business, not by the informational needs of the student protesters of Tien An Men Square. The world markets have been exploiting telecommunications and computing capabilities as they became available, not to create a global village, but to commercially exploit the one which is emerging.

The enormous power of modern information means to shape societies and events is becoming increasingly apparent. It follows that the deliberate exploitation of those means for explicit ends will become increasingly attractive and attempted. Indeed, the nexus of policymaking at all levels over the next several decades will be found increasingly at the intersections of societies and their information overlays, in attempts to devise policies to control or exploit the interactive effects between societal and informational developments.

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7As used here, the term, information overlays, represents the capabilities available to the members of a society for the acquisition, processing, and communication of information. Those capabilities include the means for information transfers within the society and with its surroundings. The availability of capabilities does not mean, however, that they will be used. There may be educational or cultural barriers to their use.
The concept of governments deliberately exploiting information technology for the purposes of the state is certainly not a new idea. The 20th century has seen several concerted attempts by governments to shape societies through the control and exploitation of information technology, mostly for the advantage of the state over its own public. That idea was taken to its plausible extreme in Orwell's *1984*. Although the communist dictatorships everywhere came chillingly close to Orwell's vision, the events of the past few years strongly suggest that McLuhan was more correct about the effects of the information technologies upon societies, particularly about the uses of mass media as they passed beyond the control of governments. While governments can and have tried to control such technologies for their own ends, the liberating effects have ultimately proved to be the more powerful and, where unfettered, have led to more competitive and adaptive societies.

Thus, until recently, the idea of deliberately controlling and exploiting the information technologies has been considered mostly by repressive regimes for application against their publics for governmental ends. In the 1970s, with the advent of microchip electronic devices for the mass market, a reversal began – as evidenced in the revolutions in Iran (1978-79) and the Philippines (1983) – with information technologies being exploited by societies to help in the overthrow of their governments. Now that these technologies have

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*To be sure, radio broadcasting (e.g., Radio Free Europe) has, for decades, been directed toward closed societies by outside governments or agencies which wanted to liberate rather than suppress their audiences. However, such positive efforts have neither been as common nor as successful as those undertaken by repressive regimes. While international radio communications have been available to the world publics for more than half a century, international television, available only in the last decade or so, represents a quantum jump in the amount and credibility of information about other societies. Obviously, being able to observe people and events, in addition to hearing them, makes a big difference in the acceptance of information. As one writer put it, "the power of the video and satellite underground was that, unlike Western radio broadcasts such as Radio Free Europe and the British Broadcasting Corp., it offered visual proof that made its message undeniable." (Rosenstiel, "TV, VCRs Fan Fire of Revolution," *Op. Cit.*)

proven themselves more effective in liberating rather than repressing publics and essential to societal productivity and competitiveness in world markets, a different problem for governments presents itself:

Can governments deliberately and constructively exploit the information technologies for their liberating and enabling effects within their own publics and, no less importantly, within other societies which might benefit?

The effects of information overlays upon the most developed Western societies, while not completely understood or appreciated, have at least some empirical basis for extrapolation. For example, the potentials of cellular telephony have not been entirely predictable, but neither have they been a complete surprise. Similarly, the market for facsimile machines may have been better anticipated than some of their peculiar uses. Thus, in the developed Western nations, a government's policymaking to exploit the information technologies for its own public can proceed with reasonable confidence based upon experience and the unfettered voices of that public.

What happens, though, when a Western government attempts to exploit the information technologies for the liberating and enabling effects that it could have for another society which may have been repressed or deprived of such benefits? It is at this point — at the intersection of rapidly expanding information technologies and a foreign culture — that the uncertainties compound to confound confident policymaking.
II. THE MISSING THEORIES

Unfortunately, the theoretical basis for such policymaking is considerably smaller than the theoretical bases that now guide economic, military, and even political policymaking within democratic societies. Although economists often differ in their estimates of the effects of a particular economic policy, their predictions are derived from theories or models that can be referenced to a rich literature. They can (and do) use those theories to predict how societies—even foreign societies—will organize themselves around sources of capital and labor, how wealth is distributed in societies, and how certain economic practices will lead to changes in societies.

For example, economists have theoretical and empirical bases for speculating about the economics of ancient societies—how economic factors shaped those societies and their destinies. If we had comparable informational theories, we should be able to describe how those same societies were shaped and evolved through the forms, flows, and contents of information exchanges. We can hardly anticipate what information capabilities will do to future societies if we don't have theories that allow us to show how they influenced past societies.

The theoretical knowledge pertinent to the interactions between societal and informational developments is currently divided among several fields, including:

- Information theory, dealing with the nature and structure of information and its communication;
- Cybernetics, emphasizing the information-processing mechanisms that generate purposeful behavior;
- Social systems analysis, treating aspects of societies, such as economics, politics, or international relations, as systems of interrelated elements;
• Psychology, particularly those branches (social, cognitive, and organizational behavior and political psychology) which have studied how different societies, groups and individuals exchange information; and
• Social anthropology, devoted to social structures and functions, including both political and economic anthropology.

Of these, the last appears to be most centrally located with respect to the interactions between societal and informational developments because "it alone among the sciences of man treats him both in his physical and sociocultural aspects [and addresses] cognitive and valuational aspects of the culture with regard to subject matter."\(^1\) Although there are now recognized fields of science and bodies of literature for political and economic anthropology, there is no corresponding field or body for informational anthropology. Marshall McLuhan, who was the first to associate psychological and sociological phenomena with the informational media available to modern societies,\(^2\) was controversial in large measure because he was without peers in this void. As a consequence, we find ourselves with limited experience or knowledge to base our predictions of the effects of changing information overlays upon different societies. We don't know enough about how information flows or reposes in different societies or how information capabilities — for transmission, processing, and communication — can change societal structures or motivations. The technical means have evolved so dramatically, so recently, through the development and ubiquitous application of the microchip that our insight has not kept pace. And what we do know (or think we know) may apply mostly to the the highly-developed Western societies which have been most responsible for both the development and exploitation of the technologies.


III. FROM INFORMATION POVERTY TO ABUNDANCE

[The new personal electronic media] have brought geographically distant groups with like interests together for common activities and have allowed people around the globe to exert power against their governments, societies, and institutions. For the first time in history, these media have furnished the means for distributing individually crafted ideas and information on a massive scale, instantaneously, cheaply, and globally.1

The quantitative dimensions of the revolution in communications — the enormous growth of circuits and capacities, the compressions of time for the exchange of information — are widely appreciated; but the revolution is also qualitative. Throughout human history the means for mass communication were limited to the few-to-many (e.g., publishing and broadcasting) and the one-to-one or few-to-few (e.g., correspondence and telephone). With the onset of computer networking in the 1970s, many now have the opportunity to communicate directly with many. For the first time, every individual can be given the power heretofore reserved to publishers and broadcasters.2 Even our limited experience with the electronic networking of computers suggests that the effects upon societies, such as business and political hierarchies, could be profound.

In the world of relative poverty in communications and information that has existed up to the current information revolution, theories about the interactive effects between societies and their information overlays have been no more prized than economic theories would have been in a world condemned by a lack of resources or technology to economic poverty. Abundance in economic or military means, and in the

2For this formulation of the dramatic change in the qualitative nature of communications, we are indebted to our colleague, Norman Shapiro, who has stressed the significance of that change in human affairs.
opportunities to exploit them, have a long history in human affairs; mass means for communication and access to information have not. The invention of the movable-type printing press, like the invention of gunpowder, was a stunning development in the diffusion of power; but the effects upon societies, while ultimately profound, have evolved slowly, almost imperceptibly over time. Indeed, we still live in a world where the majority of its population cannot access significant amounts of information from printed media.

The modern information technologies have suddenly thrust us into an era where the need for theories about the interactive effects between societal and informational developments will be highly prized; yet we are without the long experiential base from which such theories are usually devised. **We find ourselves in a position similar to that of the military policymakers after the development of the atomic bomb:** The destructive means available had suddenly changed from one of relative paucity to one of mind-boggling abundance; and the experiential basis for military theories in the new era was inadequate. The development of new theories that would serve as a new and stable basis for military policymaking took several decades. The revolution in information capabilities is no less profound in the scale and scope of change — and neither are its probable effects upon societies.

There is another similarity in the effects of the atomic bomb and the microchip: Strictly speaking, means for mass destruction were available prior to the atomic bomb, but producing that effect took time — usually months or years. The atomic bomb suddenly compressed the time required to achieve the same effect by several orders of magnitude. Similarly, the microchip-induced revolution in communications is compressing the time required for mass broadcasting of information on current events from hours (wire services and newspapers) to real time (videocameras and satellite links). In both mass destruction and mass broadcasting, it is not just the effect that has changed, but also the time required to produce the effect. It is the compression of time which produces revolutionary impacts upon the intended victims or audiences.
There can be no doubt that the experiential basis for developing theories about the interactions between societies and their information overlays will grow over the next several decades. In the meantime, information and social policies will be devised heuristically to cope with problems or to exploit opportunities as they arise. The question for research at this point is not whether adequate knowledge or theories will eventually evolve to support such policymaking, but whether that process can be significantly accelerated through research undertaken now.
IV. THE RESEARCH IMPERATIVES

As aspiring theorists of the effects of information technologies on different societies, we face a situation much like that which the first economists or first political scientists must have faced: There is little intellectual precedent to guide our thinking. Before the conceptual frameworks will be adequate to express the issues, considerable experimentation with alternative theoretical formulations will undoubtedly be required. Although current economic theories and models may still have many acknowledged inadequacies, economists do have an established vocabulary of concepts with which to reason and a portfolio of models or schemas that can be "cut to fit" to the needs of particular problems.

Thus, research aimed at improving our understanding of the impact of information technologies upon societies must first contemplate significant ground breaking even before cogent argument will be possible between contending theories and models. One of the earliest challenges will be the creation of the intellectual frameworks, including the language, necessary and sufficient for expressing the models that will be formulated to relate the natures of information and societies. Several such frameworks may be required, for just as there are both macro- and micro-economics, so too might there be different frameworks for discussing information's impact on mass culture, political power structures, or economic activities.

As with any new field of study, research into the effects of information technologies upon societies must combine observation and theory to produce a growing corpus of ideas that will eventually provide the foundation for a mature discipline. Of these two, we focus here primarily on the development of theories or models because it is the striking lack of such that presently hinders cogent reasoning about (or even recognition of) the empirical evidence. There is no question that insightful observation of events both current and historical will be vital in such an endeavor. However, to the extent that such
observations are possible at all, the means for making them are already at hand.

Models of information's role in society may have little similarity to basic economic or political models due to the volatility of information and the strongly nonlinear effects information can have on human behavior. Highly nonlinear phenomena also occur in physical, economic, and political systems, but due to the difficulties associated with nonlinear mathematics, research in these fields has become commonplace only recently.\(^1\) Previous work in these fields has emphasized linear effects, negative feedbacks, and stable solutions. A general investigation into nonlinear problems had to wait for the availability of abundant computer power, which has allowed the investigation of nonlinear phenomena through computer modeling. Similarly, one of the most promising tools to accelerate our acquisition of knowledge about the impacts of information technology is a product of the very revolution we are trying to understand.

V. THE COMPUTER AS LABORATORY

From its very beginning, the computer has been a powerful tool for research.¹ As reliable "number crunchers" - to synthesize data, calculate tedious series expansions, perform iterative calculations, and simulate complex systems - computers enhanced and enabled research much more than they changed its nature. However, the advent of the personal computer little more than a decade ago greatly expanded the capacity and availability of computing power, permitting several new research techniques that would earlier have been impractical even if they had been conceivable. The computer, in addition to serving as an aid to research in the laboratory, could also be a laboratory in itself where experiments - the principle source for observations - are conducted in the pursuit of knowledge. For the first time, insights into complex physical phenomena could be derived from simple processes that were created inside computers and have become accessible to us only through computers. Several aspects of this computer-driven revolution in research are pertinent to our interest in the effects of information technologies on societies.

The abundance of computational power has provided new approaches to understanding nonlinear phenomena that had defied solution either in the human mind or with the computational aids previously available. These phenomena include a variety of unstable and, therefore, unpredictable physical systems, such as three-body trajectories, turbulence, and weather. The use of the computer in the exploration of these phenomena has been different from its prior use in "number crunching" to the solutions of linear problems. Instead of the computer being used to spit out answers, it became a window through which to view a process or path that had no end point. Instead of working through large and

¹Electronic computers were first used in 1943 to break the German codes during World War II - a significant event marking the beginnings of the information revolution. See Jozef Garlinski, The Enigma War, Charles Scribner's Sons, New York, 1979, pp. 147-149.
complex sets of equations to an answer, simple recursive equations or algorithms were iterated endlessly to produce patterns suggesting many natural phenomena. The computer was being used not just as a huge, lightning-fast adding machine, but much as a laboratory oscilloscope to observe the patterns of processes created entirely within the laboratory computer.

The observation of these nonlinear processes on the computer has stimulated a number of developments:

- new mathematical fields, such as chaos theory\(^2\) and fractal geometry,\(^3\)
- data compression for scene generation and special visual effects,
- cellular automata\(^4\) and artificial life experiments,\(^5\)
- theories for many biological phenomena ranging from ecology to neurophysiology to the origin and evolution of life,\(^6\)


\(^6\)A sampling of works from this stimulating and complex field includes:

• models for social and economic phenomena that include positive feedback effects, innovation, and other "self-organizing" properties.  

Another pertinent aspect of the computer as a laboratory is the development of what we have chosen to call emulations – the creation of simple algorithms inside computers which demonstrate behavior that can be recognized in one or more physical systems. For example, the behavior of cellular automata, driven by simple algorithms on a computer screen, may be recognized as similar to certain biological processes. The differences between these kinds of emulations and the more familiar computer simulations is important to what we are proposing here.

One of the most common uses of computers in conventional research is the simulation of complex systems, where known (or assumed) physical processes are represented in sufficient detail so that their behavior can be more accurately predicted or faithfully portrayed. In effect, these simulations permit the portrayal of very large and complex systems by the summing-up of the effects of many contributing processes whose behaviors are sufficiently known or assumed for them to be deliberately modeled. The contribution of the computer in these simulations is its prodigious accounting capabilities – its ability to keep precise books on many simultaneous processes. The results of these simulations can (usually) be checked against tests or expectations of the physical system, piecemeal or in the aggregate.

The use of computers for research through emulations has been quite different: The computer has been used to follow the unpredictable trail of a few simple equations whose behavior and interactions, when observed, may (or may not) provide insights and hypotheses about underlying physical processes in any number of unspecified systems. Instead of deliberately modeling the observed behavior of the components of a specific system, models are used to discover and explore behavior that may help to explain what has been observed in one or more physical systems. Such emulations are more useful for the development of theories about processes than they are for the prediction of physical systems.

The defining difference between simulation and emulation, as they have been described here, is in the expectation of verisimilitude. In simulations, deliberately selected components of a particular physical system are modeled to faithfully replicate their behavior and thereby predict the behavior of the physical system on certain aspects. In emulations, some observed (perhaps unexpected) behavior in a computer program may be related to some observed behavior in a physical system, indicating a possible, unexpected relationship in underlying processes.

Many of the phenomena being investigated using emulations involve the emergence of macrostructures from the iteration of microscale nonlinear processes. For example, cellular automata may evolve into stable patterns that would not be anticipated from their motivating algorithms. Because most of the societal effects in information technology involve the organization of social activity through information flows, models of these phenomena may also exhibit this self organizing character.

More complex group behaviors are being emulated in other research efforts. For example, researchers at UCLA are using genetic algorithms to explore foraging and trail following behavior in artificial ants.\footnote{Their work has been described by Garry Abrams, "Bugs With Byte," Los Angeles Times, September 21, 1990, p. E1. Further details are available in an undated paper drafted for publication by David Jefferson, et. al., The Genesys System: Evolution as a Theme in Artificial Life, UCLA.} The UCLA researchers make no claim that they are simulating the behavior
of ant societies. Rather, the UCLA researchers have demonstrated the ability to emulate some behavior found in ant societies (trail-following and genetic evolution) and thereby undertake controlled laboratory experiments about phenomena related to life. Other efforts to examine biological or ecological phenomena using computer emulations include studies of other insect societies, studies of ecological systems, studies of developmental mechanisms, and studies of evolutionary processes. Similar methods have been employed to investigate non-standard models for economic and political phenomena.


13 See for example: Anderson, et. al., "The Economy as an Evolving Complex System,"
Research that is likely to be closer in form to models that will be useful for our interests come from attempts to understand phenomena involving information flows in collectives, ecologies, or economies. A simple example is models of flocking or schooling behaviors in birds and fish.\(^4\) Rather than attempting to accurately simulate the behavior of individual animals in order to verify that these simulated animals exhibit flocking behavior, exploratory modeling with emulations can address (even in the absence of data) the question of what are the simplest individual behavioral rules that can produce flocking.

Many of these developments were anticipated at the very beginning of the modern computer era,\(^5\) but aggressive exploration of such concepts has been possible only with the recent abundance of computer power. Although much of this work cannot be directly applied to the problem of formulating models of the effects of the information

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technologies upon societies, it does provide a landscape against which the feasibility of the proposed basic research should be evaluated. For example, the simple algorithms of cellular automata, artificial life, and genetic evolution represent modeling constructs and research approaches which are closer to what we are proposing here than the traditional computer simulations which dominate research on physical systems at this time. **We are proposing to use the computer as a laboratory to create artificial societies and thereby explore the processes by which societies may be influenced by information technologies.**
VI. MODELING SOCIETIES AND THEIR INFORMATION OVERLAYS

Because of the exploratory and speculative nature of the enterprise we are proposing, we cannot be at all certain where computer experiments with artificial societies may ultimately lead us. Nevertheless, we can identify some obvious boundaries, starting points, and general goals. The goal of any theoretical formulation is to discover powerful fundamental concepts. Consequently, what we want from artificial societies is not detailed simulations of information flows and their effects in existing societies. Rather, we seek many different, simple models that may—when exercised in computers—exhibit surprising emergent properties that appear pertinent to many different societies, information overlays, and their interactive effects.

Initially, our simple models or algorithms are likely to be inspired by our prevailing perceptions of some of the obvious effects of information technologies in current and historical societies; but they should evolve and take on polish as we explore their relative expressive powers against competing formulations. At some point, a few of the simple models will probably appear sufficiently attractive to warrant more serious consideration and development; and that will require us to evaluate them against the available data, research, or knowledge on the particular aspects they appear to emulate. For example, a simple algorithm that exhibits self-organizing behavior similar to that we recognize as characteristic for some societies could suggest that we carefully examine the literature that might pertain to that behavior. The literature might then support or discourage further pursuit and development of that algorithm.

We expect that many conceptual models and algorithms for artificial societies and their information overlays will have to be explored and exploited if we are to capture the pertinent effects of the information technologies upon societies. The success of such exploration is by no means guaranteed, but the diversity of interesting models in other fields with similar problems is cause for optimism. If we can create
simple artificial life forms in a computer that have sufficient virtuosity and verisimilitude to serve as laboratory "animals" for interesting, controlled experiments about the causes and consequences of some elemental behavior observed in living things, then we also ought to be able to create simple societal forms. Indeed, the UCLA ants are a simple societal form in their breeding behavior, just as their trail-following emulates one behavior observed in a simple life form. The interactive movement behavior of simple societies, such as flocks of birds, schools of fish, and animal herds have been emulated in computer models with simple algorithms.

Assume, as seems likely, we can find a simple algorithm for artificial agents which, under certain parameter conditions, exhibits a tendency to form a stable hierarchy of dependent associations. A host of interesting questions immediately arise:

- Which parameters in the algorithm control the tendency and strength of the hierarchies?
- Can the algorithm control parameters be logically related to characteristics of a society or its information overlay?
- How is the structure disturbed by variations from agent to agent, by the random or systematic insertion or removal of agents?

If questions such as these have promising answers, a line of exploratory research can be opened toward the development of an artificial society that may emulate one or more aspects of a real society in response to information.

We think artificial societies can be created within computers (and displayed upon their screens) to emulate some elemental behaviors observed in human societies. Like the UCLA ants following trails, we should be able to program simple models to behave, in certain limited ways or tasks, as members of a society, with respect to their:
tendencies to establish or change social hierarchies,
communication interconnectedness with other members within the society (horizontally or vertically) and with sources outside the society,
receptivity to reprogramming themselves through external information, and
proclivities to communicate with other agents, horizontally and vertically, depending upon their relative hierarchical position within their society.

Clearly, emulating such simple, elemental behaviors among and between models inside a computer does not represent a simulation of a human society. Yet, like the UCLA ants, computer emulations of informational and societal processes could provide an excellent laboratory in which to conduct controlled experiments about the processes of change when structured, stable societies are subjected to major changes in their information overlays. The range of experiments that might be conducted in such a laboratory will depend upon the virtuosity of the emulations created. Assuming that they can be programmed to exhibit the elemental properties or behaviors listed above, it should be possible to explore what happens to the structure and stability of artificial societies when changes are made in their abilities to:

- transmit self-programming information differentially upward, downward, or laterally within their hierarchies,
- receive reprogramming information from sources external to their society, including degrees of "censorship" and counter-programming through their hierarchies, and
- receive and transmit reprogramming information within their society, including one-to-one, one-to-few, and one-to-many communications.
Just how rudimentary or sophisticated these artificial societies and their information overlays will be depends upon the computer programming problems they pose, the skills of the computer scientists who try to program them, and the capacities of the computers devoted to the research. Only the first - the difficulties of programming emulations of societal and informational structures - is fundamental to the feasibility of the laboratory research suggested here. Such research is likely to attract the interest of the most skilled of computer scientists; and they, in turn, are likely to anticipate and gain access to computers capable of executing the programming tasks they foresee.
VII. A RESEARCH PROGRAM

Undertaking and exploiting such laboratory research must be considered as a long-term basic research program. Four phases, each representing perhaps about a year's worth of work, each aimed at a different kind of proof, would provide a logical progression of the laboratory into the applied research domain:

1. **Proof of feasibility:** The question to be answered in this first phase is not whether computer models representing societies and their informational overlays can be created within computers, but whether they can be created *simply* enough and cleverly enough to be run inside reasonable computers, yet fast enough and with enough variables to make a promising laboratory for future research. The tests of feasibility are computer capacity requirements, experiment running times, and the potential dimensionality of the emulations.

2. **Proof of virtuosity:** In this phase, the question is whether the artificial societies and their informational overlays - as laboratory "animals" created in the first phase - are rich enough in their properties to have a repertoire of behavior worth pursuing. Can they be made to do lots of different and interesting things? Are there enough input or control variables to give them a promising scope of behavior in the design of experiments?

3. **Proof of malleability:** In this phase of the research, the question is whether the knowledge and control of societal/informational emulations created within computers is sufficient for the confident design and conduct of specific experiments. Do we know enough about the design of these models to evoke measurable behavior in expected directions? Do we know which design parameters will produce certain behavior and the reasons for the relationships?
4. **Proof of pertinency:** Finally, can we now relate the properties and behaviors of these emulations to real societies? Can we demonstrate that these laboratory emulations point toward certain interesting and unsuspected behaviors or interrelationships that need to be examined in real societies? Do these emulations suggest axioms or propositions that may apply to real societies?

These four phases of laboratory development leading to applied research exploitation might reasonably take three to five years. Failure to meet any of the four proof tests along the way would be cause for reassessing the research program as to both its ends and means.

The required resources appear to be modest. Two to four full-time researchers should be sufficient; but their supplementation with an equal number of part-time graduate students should be mutually beneficial in a program such as this. Initially, the team composition should be heavy in computer and information scientists, with social and behavioral scientists in support, because the critical early questions have more to do with what is practicable on computers than with what is of greatest interest in the emulation of societies and their informational overlays.\(^1\) That balance should reverse in the later phases of the program as specific experiments are designed and as the pertinency of the laboratory observations to real societies is tested.

Finally, it is worth observing that the research proposed here should be lots of fun for the researchers involved. It offers creative opportunities to build toys inside computers and watch them do both expected and unexpected things when they are wound up and turned loose. That should be all to the good because the opportunities to be creative

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\(^1\)The available laboratory tools (means) have commonly limited and, therefore, shaped the design of experiments (ends), even though we might logically prefer it to be otherwise. Just as the capabilities of available particle accelerators will limit and determine the aspects of nuclear physics that can be explored, so too we must expect that computer hardware and software capabilities will limit and determine the aspects of societies and information overlays that can be emulated.
and have fun will attract some very good researchers. That said, however, the impetus to undertake the basic research program described here obviously lies beyond toys or fun or even artificial life forms that emulate societies responding to their information overlays. There is a chain of incentives that lead straight back to policymaking for the decades ahead: Societal/informational emulations may provide the laboratory "animals" that can help us, through experimentation, to recognize the existence of some of the fundamental relationships between societies and information. That recognition may lead to insights and then to theories about those relationships; and the theories should help us to design better policies for managing the problems and opportunities at the impending peak of the information revolution - where policymaking may be urgently needed, yet urgently in need of relevant experience and knowledge.
