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# A Complex Systems Perspective to the Microsoft Antitrust Case and the Los Alamos Fire

Patrick McGuire
Zentrum für interdisziplinäre Forschung
Universität Bielefeld, D-33615 Bielefeld
(+49) 521 106-2787
mcguire@physik.uni-bielefeld.de http://athene.as.arizona.edu/~mcguire

## Abstract
We introduce the field of complex systems to the non-specialist and apply this mode of complexity thinking to a major issue in the world, namely the Microsoft antitrust case.

## Introduction to Complex Systems

The Science of Complexity has been a growing new field since the mid-1980's, with more than a handful of Complex Systems Centers or places of concentration of complexity researchers flourishing throughout the world. The main reason for the birth and recent growth of the Complexity field has been the advent of powerful and affordable computers in the 1980's with sufficiently easy-to-use tools to study systems of interacting agents. But a second important reason for the growth of complexity is the theoretical and experimental/computational advances made in this field in the 1970's and 1980's which suggested that many of the problems being studied in different scientific fields have a common universal mathematics, implying common behavior. These fields included:

1) Climatic dynamics,
2) Turbulent dynamics,
3) Biological dynamics (including population, ecological, neural, protein-folding, cardiological, and immunological systems),
4) Financial/economic dynamics,
5) Physical dynamics (displayed by chemical, optical, mechanical, electrical, statistical and thermodynamical systems).

Even now, the universal theoretical complex systems formalisms discovered 20 years ago in the sciences listed above and the practical experience gained in the studies of particular applications are being applied to almost every research field, including the social sciences, sports, politics, historical analysis, and law.

The novelty and importance of complexity are often summarized by the concept of 'emergence' – the ability for groups of agents (e.g. ants, neurons, stock-traders, nations) to exhibit behavior when acting collectively in cooperation or in competition that is qualitatively different then their behavior when acting alone. In the case of the **ant colony**, a couple of the emergent properties are the robust ability to locate and retrieve food due to the chemical communication of the ants, as well as survival of the colony due to the different specialization modes of the different ants. In the case of the **brain** composed of neurons, some of the emergent properties include manic-depression, epilepsy, consciousness, creativity, and love. In the case of **artificial and natural intelligence systems** composed of neurons, emergence gives us pattern recognition of faces, of fingerprints, of atmospheric turbulence and weather, of stock market prices, of relationships between medical/economic/social variables. In the case of the **stock and currencies market** composed of traders and economic policies, emergence can give the economy such things as bull and bear markets for years, worldwide depression, stock market crashes, market efficiency, and collective price oscillations. In the case of the **biological immune and hormonal system**, the combination of antibodies/proteins and the levels of certain chemicals, we get the incredible natural ability to combat diseases, the ability to maintain physical and mental health, as well the need to develop artificial weapons against the horrible effects of unusual viruses and breakdown of the usually robust immune and hormone systems. And in the case of the **political, environmental, social and economic world**, we find the wonderful world in which we live and which we need to learn to be better stewards, marked by such emergent properties as law, morality, spirituality, international and inter-ethnic war, fascination with sports and arts, depletion of natural and economic and human resources, the ozone hole, the greenhouse effect, slavery, monument-building, democracy, socialism, 'the Third Way', dictatorship, technocracy, the need for homeostasis and controlled growth, the arms buildup in the Cold War, complex social rules and personal/social/cultural preferences, and antitrust suits against Microsoft.

The summarizing causes of this emergence in these complex systems are two-fold:

- The web of interactions of the agents with each other and with the system of which they are part and with external agents, which allows for positive and negative feedback between individual agents, as well as for complicated collective feedback;
- The non-linearities of the agents and the non-linearities of the interactions between the agents.

Often inclusive in the concept of complexity is the ability for the complex web itself to adapt or to modify itself (e.g. to self-organize) based upon interactions within the web and upon exogenous environmental factors. The ability to grow or learn or for individual agents to be born or to die are often also hallmarks of a complex system. But without a sufficiently complex web of non-linear actors/interactions to give emergent behavior, a complex system is *not* complex. Nevertheless, evolution, growth and adaptation and other such 'slow' macro-dynamics are of primary interest to complexity researchers and may be seen as another emergent behavior of complex systems, called 'environmental robustness'. The 'fast' micro-dynamics of the non-linear web found in many complex systems is one of the root causes of this emergent behavior of robustness.

The **main** theses of the research field of complexity are:

1) Research techniques and conclusions learned in studying one example of a complex system are often directly or indirectly applicable in the study of a very different example of a complex system;
2) General formalisms, concepts, and phenomena, such as:
    a) Dynamical systems theory,
    b) Malthus' exponential growth model and its implications in a finite world,
    c) Chaos and fractal theory,
    d) Self-organization,
    e) Artificial neural network learning/training theories, 'swarm' learning theory,
    f) Statistical physics (both equilibrium and non-equilibrium),
    g) Thermodynamics, Entropy,
    h) Power-law scaling phenomena; Zipf's Law,
    i) Non-Euclidean geometry; Differential Geometry;
    j) Shannon and Fisher Information Theory,
    k) Critical phenomena and phase transition theory,
    l) Turbulence theory, spatiotemporal correlation functions,
    m) Stochastic and deterministic differential equations,
    n) Social and economic network theory, Increasing Returns Theory.

These common techniques and general formalisms offer a unifying interdisciplinary framework for the advanced study of all the application fields of complexity. Research devoted directly within these application fields can bring energy and new ideas so as to further the general formalisms of complexity theory. Often a single application when approached from the appropriate point of view will need aspects of many, if not all, of the above formalisms.

The mathematical formulations of the non-linear webs of different complex systems are often very similar, independent of the type of the complex system. Therefore, it behooves the scientific, social and economic worlds to foster the communication and collaboration of scientists between these disparate fields of application, so that they can better understand the common mathematics and common methodologies. Progress in neural-network or evolutionary learning theory may aid chemists in the control of the pathways of chemical reactions using femtosecond laser pulses. An astronomer who studies atmospheric turbulence and develops artificial intelligence (AI) techniques for astronomy may be able to use her/his computer skills in modeling complex webs of AI agents to help a sports scientist better understand and possibly improve the team strategies used in sports, and perhaps someday to improve peacemaking strategies in geopolitical situations. Or an immunologist, who is thinking beyond his/her field, may gain a key insight in how to apply T-receptor or immunological network theory to solving some of the problems of a sustainable economic world.

## The Microsoft Antitrust Case from a Complexity Perspective

To illustrate some of the ways of thinking in terms of complex systems, let us consider the last of the emergent properties in the world, as enumerated above, namely, the emergence of the antritrust suit against the computer giant, Microsoft, and the emergence of the repercussions of this suit in the computer world and in the economy (see Figure 1). Some might argue that monopoly is just a state of a system and not an emergent property. On the other hand, even some of these same thinkers may believe that the monopoly-producing structure of the political economy is *itself* an emergent property of the present economy. We do not specifically argue that monopoly is bad or good, but perhaps more importantly, that the monopoly-at-whatever-cost attitude of Microsoft may need to be revisited. Specifically, if Microsoft and other corporations (e.g. Netscape) had formed a consortium when browsers became popular in the early 1990's, then it would have been likely that all parties would have benefited. But in order to form such a consortium, it is likely that early governmental or industry-committee intervention may have been necessary. Certainly there are other possible changes to the system that could have positive long-term effects as well.

The web of interactions and agents includes:

- All the vendors and users of Microsoft products including the operating system Windows, the word processing suite Word, the spreadsheet package Excel, and the internet browser Explorer;
- All the vendors, producers and users of competing products such as those of Linux, Unix and Macintosh Operating Systems, word processing packages such as WordPerfect and Latex, spreadsheets like Lotus123, and internet browsers such as America Online and Netscape;
- Microsoft, led by founder Bill Gates;
- The Judge in the case (Thomas Penfield Jackson), the plaintiffs in the case (19 American States, and the United States federal government), the US Justice Department (led by Janet Reno), and the US Federal Trade Commission (FTC).

The non-linearities in the case include:

- The Sherman antitrust law, according to which, sees big companies that exert undue influence on their competition as being incompatible with a fluid free-market capitalistic society. The Sherman act also views smaller companies that must attempt to climb in such a tilted playing field as being victimized. In the case of Microsoft, the alleged monopolistic practices include integrating an Internet browser into their market-dominant operating system. The Sherman antitrust law is usually only enforced against companies bigger than a certain threshold size in an industry, which is by definition, a non-linearity.
- The advantages for computer users and makers of a dominant operating system with integrated applications in order to work easily and productively without having to worry about interoperability issues between operating system and applications. With even a slightly less dominant operating system, many headaches ensue.
- The number of 'bugs' in a computer product is a time-dependent, probabilistic, non-linear, multi-dimensional function of market share, programmer quality, end-user experience, management, quality control processes, interoperability with hardware and software products from other companies, etc.

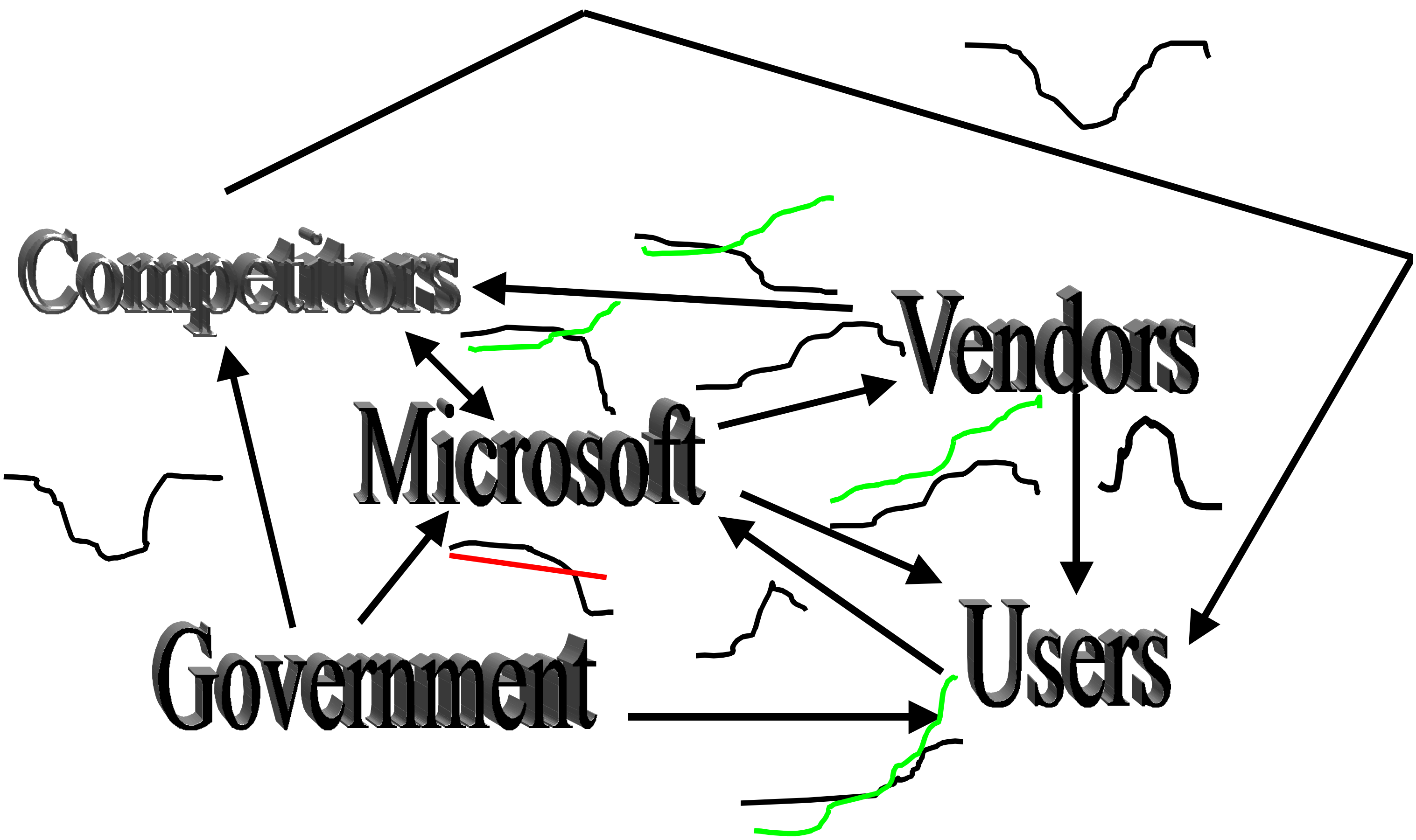


Figure 1: A caricature of the Microsoft antitrust case. This is meant to be illustrative, not definitive. The arrows between the agents show some of the interrelationships. The black curves next to the arrows show the possible positive or negative effect of one agent upon another agent at the other end of the arrow, as a function of the market share of Microsoft's operating system. The red curve shows one possible change in the non-linear web, and the green curves show some of the changes that might occur as a result of the linearization of governmental antitrust policy.

If it were not for these legal, computer-usage, and computer-implementation non-linearities or for the complex set of interactions between the players in the Microsoft case, the capitalistic system would be totally different. Possible outcomes include:

- Either exclusively one vendor in a market or too many vendors in a market;
- Either market stagnation or uncontrolled growth;
- Either with computers still being in the dark ages, or with our computers already being Star Trek–like artificially-conscious companions;

Nevertheless, this web of interactions and the non-linearities are as they are, and the emergent antitrust suit against Microsoft was perhaps inevitable or predictable given this realization of the non-linear web.

Perhaps with a different non-linear web that had different types of adaptation to a changing world, then an antitrust suit against Microsoft could have been circumvented. For example, if the antitrust laws were more linear or enforced with less time delay, then enforcement and compliance to alleged or possible future antitrust violations or transgressions might have occured at an earlier stage when the company was smaller and younger. In that case, the world impact of alleged monopolistic tendencies and the subsequent legal proceedings might have been much less severe. Perhaps such a 'linear' change in the legal system could accelerate economic growth or make economic growth 'better' by making it more sustainable, as it might teach and foster collaborative practices among companies that would otherwise only be competing for market share without caring about the others' welfare.

Other changes of the non-linear web might also make for a more productive computer world, such as introduction of stabilizing nodes and connections in the web. For example, the UNIX model of having several different vendors supply different versions of an operating system with wonderful cross-platform capabilities might be a model for the IBM or Macintosh operating system. This is much of the reason for the recent limited success of Linux. Unfortunately, due to the Microsoft Windows monopoly in the PC market, software application development (e.g. sound and modem drivers, and other applications like Quicken and America Online, among others) has been limited and Linux market share has also been limited in the near term. But if several interoperable Windows operating systems companies existed or if Linux or UNIX had perhaps three times the market share on IBM-PC architecture that it now has, then application development for non-standard platforms would be much healthier. On the other hand, with too much diversification of operating systems, coping with the computer world could be much more frustrating than it is today.

Certainly, the computer world is a highly complex one, marked by the non-linearities and a complex, evolving web of interactions that make it a reasonable system to study to see if it can be improved. And it serves as a decent example of a complex system, with language that almost everybody can understand, based upon the wide-spread experience of the populace with computers and software. At Stanford and the Santa Fe Institute, Brian Arthur's work on applying non-linear probability theory to market dynamics has given the world detailed micro-economical explanations for certain macro-economic phenomena found in monopolistic markets, such as: increasing returns, customer groove-in effect, network effects, path dependence. Perhaps a scientist will soon develop a better general complexity theory of monopolies and of the antitrust legal system which will allow us to avoid (or handle better) situations similar to the current Microsoft antitrust 'fiasco'. Certainly with such mergers and acquisitions pending now as America-Online + Time-Warner, Vivende + Seagram's/Universal, and Deutsch-Telecom +

Voicestream (among others), such a complexity theory of monopolies & antitrust law would contribute to the ultimate future health of the world economy.

# The Complex Los Alamos Fire

But perhaps, more importantly, using complexity thinking more extensively in the world can prevent catastrophes and lead to a world that is more robust and manageable. For example, in the recent Los Alamos 'controlled' burn, mistakes were made by numerous parties that could have been avoided if people were more aware that in a complex system like forest management, little things make big differences in the outcome. The U.S. Secretary of the Interior, Bruce Babbitt, and his team reacted to this calamity by showing full realization of this 'little things matter' concept, as well as full realization that in this situation, no one person should be blamed fully. They also realized that there were systemic problems in the US forest management program that severely contributed to the unmanageability of the Los Alamos 'controlled' fire, and they recommended and are implementing procedures to reduce the likelihood of similar problems in the future. This complexity perspective is a remarkable and mature outlook, which should be taught to more leaders and managers.

***Remembrances and Acknowledgements:***
The author sadly remembers the horrific smoke clouds emanating from the Los Alamos fire that could be seen from 200-300 miles away on a recent trip to Albuquerque and Ft. Sumner in New Mexico. He also remembers the tempered joy about 10 days later, when in New York waiting to go overseas to his present position, when he read about the Interior Department response to this fire mismanagement. The author is an active user of both the Linux and Microsoft operating systems, and recently discovered some of the utility of the Microsoft Active Desktop browser, despite using the Netscape browser predominantly for 7-8 years.

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## *References:*

W. Brian Arthur:
'Positive Feedbacks in the Economy,' Scientific American, February 1990.
'Increasing Returns and Path Dependence in the Economy',
(Ann Arbor: University of Michigan Press, 1994)

*Cerro Grande Prescribed Fire, Independent Review Board Report*, May 26, 2000, Bruce Babbitt and the Independent Review Board: State of Florida, Division of Forestry; U.S. Department of the Interior, Bureau of Land Management, U.S. Department of Agriculture, Forest Service, White Mountain Apache Tribe
http://www.doi.gov/secretary/reviewteamfinal.htm

William A. Barnett (Editor), *Economic Complexity: Chaos, Sunspots, Bubbles, and Non-linearity (International Symposia in Economic Theory and Econometrics),* Cambridge, 1989.

P. Blanchard, R. Lima, L. Streit, R. Vilela Mendes, `Proposal for the ZiF Complexity Research Year: "The Sciences of Complexity: From Mathematics to Technology to a Sustainable World" ´, 1998.

Eric Bonabeau and Guy Théraulaz, ‘Swarm Smarts’, *Scientific American*, March 2000.

William A. Brock, 'Chaos and Complexity in Economic and Financial Systems', in G. von Furstenburg (ed.) *Acting Under Uncertainty: Multidisciplinary Approaches*, Boston, MA: Kluwer, 1998.

M. Dorigo & L.M. Gambardella:
‘Ant Colonies for [solving] the Traveling Salesman Problem’, *BioSystems* **43**:73-81 (1997); ftp://iridia.ulb.ac.be/pub/mdorigo/journals/IJ.15-BIOSYS97.pdf

Dominic Gates, interviewer, ‘W. Brian Arthur Talks to Dominic Gates,’ Pretext Magazine, May 1998, http://www.pretext.com/may98/columns/intview.htm

Bert Loan, ‘Resistance is Futile: Lessons From the Uncertain Future of Microsoft’, The Yale Political Quarterly, http://www.yale.edu/ypq/articles/dec99/dec99a.html

J. Garrett Ralls, ‘The Nature of Chaos in Business: Using Complexity to Foster Successful Alliances and Acquisitions’, Houston, TX, USA: Cashman Dudley, c1999.

Steven H. Strogatz, *Nonlinear Dynamics and Chaos: With Applications in Physics, Biology, Chemistry, and Engineering (Studies in Non-linearity)*, Perseus Press, 1994

Garnett P. Williams, *Chaos Theory Tamed*, National Academy Press, 1997

**Also see:** two of several extensive web-based bibliographies at:
http://www.soc.surrey.ac.uk/~scs1ec/complex.html (from Edmund Chattoe)
http://www.santafe.edu/sfi/publications/Bookinforev/alphalist.html (from the Santa Fe Institute)