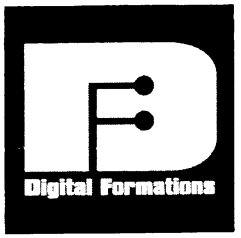

Steve Jones
General Editor

Vol. 44

PETER LANG
New York • Washington, D.C./Baltimore • Bern
Frankfurt am Main • Berlin • Brussels • Vienna • Oxford

SUB Hamburg

A 2009/11504

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Digital Contagions

A Media Archaeology of Computer Viruses

PETER LANG
New York • Washington, D.C./Baltimore • Bern
Frankfurt am Main • Berlin • Brussels • Vienna • Oxford

Library of Congress Cataloging-in-Publication Data

Parikka, Jussi.
Digital contagions: a media archaeology of computer viruses / Jussi Parikka.
p. cm. – (Digital formations; vol. 44)
Includes bibliographical references and index.
1. Computer security. 2. Computer viruses. 3. Computer networks–
Security measures. I. Title.
QA76.9.A25P376 005.8–dc22 2007006863
ISBN 978-1-4331-0093-2 (hardcover)
ISBN 978-0-8204-8837-0 (paperback)
ISSN 1526-3169

Bibliographic information published by **Die Deutsche Bibliothek**.
Die Deutsche Bibliothek lists this publication in the "Deutsche
Nationalbibliografie"; detailed bibliographic data is available
on the Internet at http://dnb.ddb.de/.

Cover design by Lisa Barfield

The paper in this book meets the guidelines for permanence and durability
of the Committee on Production Guidelines for Book Longevity
of the Council of Library Resources.

© 2007 Peter Lang Publishing, Inc., New York
29 Broadway, 18th floor, New York, NY 10006
www.peterlang.com

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Printed in the United States of America

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Acknowledgments

Doing research is a heterogeneous assemblage, and books actualize only through various force fields. These include at least economic, institutional, social, conceptual, and affective elements. Economically I am grateful to The Finnish Cultural Foundation, Emil Aaltonen foundation, Jenny & Antti Wihuri foundation and also the TIESU-project, funded by the Research Program for Advanced Technology Policy (Proact), the Ministry of Trade and Industry and the National Technology Agency, Tekes.

Institutionally, I want to thank the departments of Cultural History and Digital Culture at the University of Turku (Finland) and all the colleagues there for feedback and a pleasant working atmosphere. A major part of this work was, however, written "in-transit", and I want to extend a thank you for their hospitality to the departments of Media Studies at the University of Amsterdam (professor Thomas Elsaesser) and the Berlin Humboldt University (professor Wolfgang Ernst), respectively.

As for individuals, so many are to be thanked. Hannu Salmi, Matthew Fuller and Jukka Sihvonen gave continuously invaluable advice. Charlie Gere and Tiziana Terranova are to be commended for their input at a late stage of the work.

Others that should not be forgotten include (in no particular order): Raine Koskimaa, Tony Sampson, Sakari Ollitervo, Milla Tiainen, Pasi Väliaho, Matleena Kalajoki, Katve-Kaisa Kontturi, Ilona Hongisto, Teemu Taira, Geert Lovink, Olli Pyyhtinen, Floris Paalman, Petri Paju, Petri Saarikoski, Tanja Sihvonen, Jaakko Suominen, Silja Laine, Maija Mäkikalli, Mikko Hyppönen and the various people I interviewed for the book.

Thanks (again) to Henri Terho for his expert work with the layout of the book. In addition, without the help of Sirpa Kelosto I would have been lost.

The people at Peter Lang were extremely professional and helpful when finishing this book. Of course, a special thanks goes to Steve Jones as the editor of the Digital Formations series.

Conclusions: Media Archaeology as Ecology

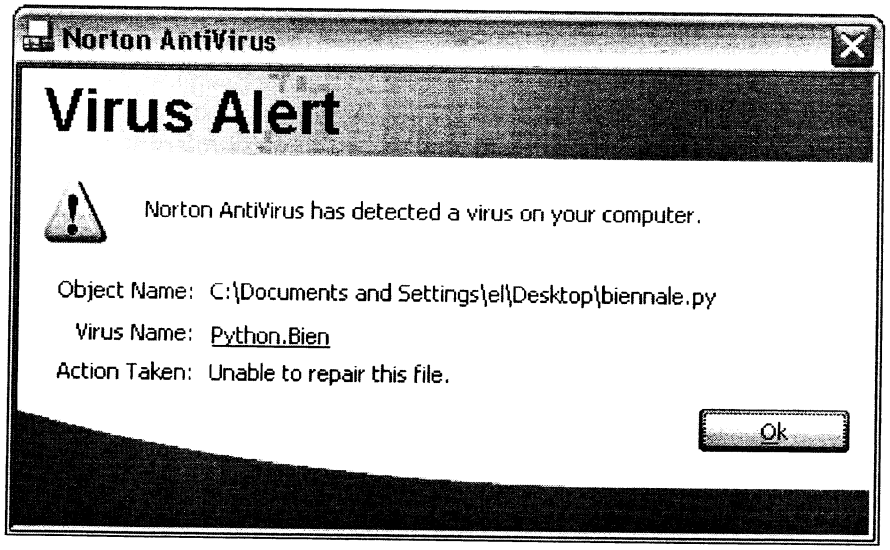
In 2002, the Frankfurt Museum for Applied Art added a new type of object to its collections: the computer virus, or more specifically viral code. In addition to its classical collections of ceramics and art from Islamic and East Asian countries, the esteemed museum was willing to consider these pieces of software worth archiving. The task was part of the "I Love You" exhibition curated by Franziska Nori, who emphasized the active role a museum has in preserving and defining cultural memory:

> In addition to collecting and preserving objects, a museum's purpose is to provide cultural contexts and distinctions, whereby the observer is encouraged to rethink his or her own perception of the world of things. Not only do museums serve as a society's cultural memory, they are also places for communicating and researching the new realities and models which are relevant to society. The paramount question: What is digital culture today and what will it become in the age of the information society? not only determines the direction of today's artistic production but should also encourage cultural institutions to examine their own task.[1]

In this perspective, viruses do not merely represent an example of malicious viral code but are part of a cultural-historical assemblage of digital culture. Aptly, they are archived as an integral part of the memory and future of network culture and consequently are adapted as explicit parts of the discourse network of digital culture. In other words, the issue is not just about the technical fact of viral code but also about the media ecology of network culture.[2] The perception of viruses as accidents can be channeled into a new seriality that gains consistency and hence creates a minoritarian archive, or a memory, of digital culture. This is the task of temporally oriented cultural analysis: to multiply events and accidents and create heterogeneous assemblages that endure and sustain a new understanding of practices and discourses; to repeat the accidental so that it does not remain

anomalous but opens up as a new, creative horizon in theoretical and perhaps in practical spheres of action as well. The virus, as argued throughout this book, is not merely "noise", in the sense of being a random pattern without sense, but a certain rationality. This is not only a metaphor but reflects how noise has become refigured in the age of Shannon and Weaver's information theory. Noise is something programmable and hence a mode of algorithmic rationality, which reflects its status as a cultural object. Noise is not just noise but something that can be cultivated, as in early sonic media arts from Edgar Varése's musical pieces integrating "noise" as organizatory element to John Cage and, for example, the experiments with feedback turned into the new aesthetic craze of rock music (distorted sound). Stochastic patterns and turbulence are taken much use of.

The virus can be seen as a key cultural condensation point of network culture, a sort of fundamental object. Yet, as demonstrated, in a way it is not an object but a network. Opening up this seemingly solid piece of technicality and software reveals a world reaching out in time and space, across scales and various platforms. The virus, then, is a passage to analyzing certain traits of formation of network culture, here analyzed specifically in terms of security, body, and (artificial) life.



During recent years, various net art projects have addressed computer viruses as a curious aesthetic and media cultural phenomenon. One such example was the Biennale.py net art virus from 2001, which was distributed on T-shirts and sold on CD-ROMs ($1,500 each). With the virus, computer code became a media performance. Image by Eva and Franco Mattes (0100101110101101.org), source: <http://0100101110101101.org/download/biennalepy.html>.

The first chapter engaged with the tactical creation of fear inherent in network culture. Given the security aspects of this media ecology, computer viruses and worms connect to the agenda of risk society and risk filtering in contagious media. This is part of what I called "viral capitalism"—the ability to translate seemingly hostile cultural flows into an integral part of the production of digital software and services in the form of the security industry. Viruses and similar semiautonomous programs were not a security concern during the 1970s, even though several fiction writers depicted virus-like and worm-like program patterns as potential intruders into computer networks. Only after the mid-1980s and the 1988 Morris worm did self-reproducing and self-moving programs enter a new assemblage in which they were christened as malicious software. The nonvisual nature of the digital code of viruses was effectively remediated into audiovisions through mass media channels, whether in texts or on television news and, during the 1990s, in movies. Here, the media assemblage itself demonstrated patterns of contagion in its handling and adaptation of this perception of digital risk.

The risk society of network culture can be seen as a second-order capitalist system from which noise is not excluded. Instead, the more tolerant systems are, the more strongly they function. Rigid systems, trying to cast out their parasites, noise, and viruses, do not last as long as a system accustomed to the deviant. "Flexibility" became a key word in network society, and in the software context the change can be situated in the 1980s. There is no mathematical possibility that a system can be totally virus-free, claimed Fred Cohen. Basically, since then, various counteractions have aimed not at total security and control of threats but "only" at adjustment and toleration of uncertainty and risk. Risk management became a key concern of software as well.

To be sure, self-reproducing software existed before it was labeled malicious. Experimental reproductive software had been programmed in various computer labs and university departments in the United States since the 1950s. Such experiments could perhaps be thought of as probing ideas of "sentient" software and computing that was not merely about simple deductive number crunching. Software could be used in parallel, interactively, and in network contexts. Of course, the first "real" viruses spread only during the 1970s, in the early networks, such as ARPANET, and in science fiction. It would be tempting to read these descriptions of fictitious viruses as predictive warnings of worms and viruses breaking loose and causing havoc in national and international data networks, as, for example, in John Brunner's *The Shockwave Rider* (1975). However, fiction literature of the past is not merely a recapitulation of what came to be; it should be read as offering alternative viewpoints to viruses, a new imagination.

Viruses were distributed in various media, and language seemed to occupy a special place in the thematics of the viral. "Language is a virus", claimed William Burroughs in his peculiar style, claiming that basic media processes are chiefly about imitation and reproduction. In a parallel manner, I claimed in the second chapter that the media ecology of viral capitalism acts through special order-words and incorporeal transformations. Instead of speaking of the metaphorics of computer viruses and worms, I chose to approach the issue as one of the pragmatics of language: how are these pieces of code turned into malicious software, and how are the order-words of AIDS, virus anxiety, digital hygiene, and computer immunology used in the diagrams of network culture? During the 1980s, the fear of bodily intrusion by AIDS and general interest in viral issues tallied well with the underscoring of digital viruses as the key risk to future societies of network computing. In other words, the language of the virus did not so much represent but enforce a way of seeing computer culture as a biological system and how outsides and insides are distributed in such a system. Immunology played an interesting role here, just as it has played in biology. Healthy bodies have been defined and constructed in terms of immunological knowledge, especially since the 1980s, and soon this use of concepts infiltrated computers both via professional studies and via popular computing magazines. The idea of computer systems having an immune layer was meant to imply that there is a "self" in computers that should be protected against "infiltrators" such as viruses. Yet, in another context, the idea of flexible immunity gained ground. Of course, computers could not defend themselves: the pragmatic figure of a "responsible user" was created to channel these types of ideas into actions. Responsible use included being consciously motivated to keep one's computer safe from untrusted software (often labeled as pirate software). This was not merely to protect oneself; it was meant to signal a general responsibility of the whole of the computer community. The language of AIDS and protection from contagious diseases was widespread.

In Chapter 2, the analysis of the "body" of network culture took advantage of Deleuze's reading of Spinoza: "Bodies are distinguished from one another in respect of motion and rest, quickness and slowness, and not in respect of substance."[3] Bodies are analyzed, then, as relational entities, defined by the networks they are able to form (and networks they are able to adjust to). Bodies do not preexist their relations; an ethological (and in my take ecological) perspective focuses on the capacities to affect and be affected. This implies the need to develop much more complex models of bodies and boundaries (and hence, for instance, immunology) than the inside–outside models with their warlike implications suggest. The Spinozian ideas resonate strongly with, for example, the autopoietic theories

of Maturana and Varela, where the issue of coupling is primary. Organisms exist only as intimately coupled to their environment, where the border between the two is to be considered as a folding: a continuous surface that stretches from the outside to the inside like a Möbius strip, a strip with multiple dimensions but all testifying to one common reality. This relates closely to Spinoza's claim that there is one voice, one substance connecting its various attributes. Among the alternative ways to think of bodies discussed earlier was Ludwig Fleck's critique of closed, self-contained individuality from the 1930s. In computer science, Terry Winograd and Fernando Flores proposed models of breakdowns to be incorporated at the center of computer systems design. This implied a whole new approach to systems, where "healthy bodies" were not defined in terms of nonfrictional, self-enclosed action but as interconnected assemblages where breakdowns revealed the complex networks that sustained the functioning. Computer systems were not pristine bodies without holes, accidents, or inconsistencies but symbiotic bodies that relied on each other in their daily operation. This focus on breakdowns leads to an understanding of the interconnected nature of computers as networks and assemblages, where accidents are, always, internal to the functioning of the machine. In other words, autopoietic systems, or machines as Deleuze and Guattari name them, rely on external elements for their existence (a complementarity with the world), yet this is doubled with an element of differing in relation to the world (an alterity in relation to other machines, virtual or actual).[4]

Such themes relating to Spinozian ethologies and ecologies of bodies can be further expanded. There is a certain potentiality in bodies, and this potentiality is realized in its experimental relationships with the world. Now, this perspective is useful in the context of network culture and software as well. Programs have affects—they can form relations and are part of a vast network of relations, like the virus with its three primary technical affects: (1) the copying routine that enables the distribution of the virus; (2) a trigger that switches the viral code into active mode (for instance, with earlier viruses, a certain date or a certain number of computer boot sequences); (3) a payload, which is often the level users perceive (playing a tune, displaying a message, or something directly harmful). Yet, in addition to such technical ethologies, there exists a much vaster sphere where "bodies" are formed and interact on scales ranging from ideas to politics, economics to aesthetics. This can be seen as the problem of the concept of the body in its Deleuzian and Spinozian take: it is much too broad. The positive side is that exactly as a consequence of this abstractness we are able to see how far a concrete object's relations span. They are not always merely local (although they span from a certain position).

With an eye on potentiality, I emphasized in Chapter 3 how the virus is excess, not merely a product of power/knowledge *dispositifs* that mark it as malicious software. Writing the history of viral assemblages as part of the ideas of complexity and networking, I ended up mapping the countermemory, the genealogy, of the phenomenon, which also accentuates the thematics of life as coupling. The viral is not reducible to its defining contexts; following Deleuze, we can think how the lines of flight and the deterritorializing machines of connectivity come first.[5] Viral patterns of self-reproduction, communication, and even potential emergence have attracted the interest of computer scientists, hobbyists, hackers, and artists for decades. In other words, we have various viralities working in this media ecology, viralities that are not reducible to their technological characteristics but constitute a diagram or an abstract machine that pilots the concrete machines: the viral code is continuously articulated in contexts of (viral) media and (viral) capitalism, without forgetting, for example, the conceptual thematics that have been articulated from Burroughs's idea of the language virus to the meme theory of Dawkins and Blackmore and on to perhaps the arguments for a (viral) philosophy that I mapped in the epilogue of the previous chapter. This mode of thought that proceeds as ecological couplings does not pertain only to "philosophy" as an academic discipline, but can also be found in the practical work done in various artificial life projects. As Isabelle Stengers noted, there is a certain potentiality of creative neomaterialism in ALife research that would map new ways of becoming. ALife projects such as Ray's Tierra digital ecology can be seen in this way as tapping into the machinic phylum and looking for ways to approach the world as itself material, active, and self-organizing. As these themes have spread through the field of philosophy and cultural analysis via the work of, for instance, Deleuze and Guattari, DeLanda, and Parisi, there is a parallel movement going on in computer science and experimental programming that looks for the potential inherent in the phenomenology of software objects.

Thus, as we address artificial life and musical-ethological views of technology, we can also view computer organisms such as viruses as affordances and potentials. As ALife and several scientific (and practical) projects close to it draw extensively from ideas of symbiosis and emergence, viruses also belong conceptually to this group as elements of interconnection and folding. Just as artificial life is not "only" a scientific field that closes on itself, but also one that deterritorializes (or "deconstructs", as some would say) fields around it (biology, technology, etc.), so viruses might be understood not exclusively as technical pieces of code that infect programs. They, too, can be taken as active "tools to think with" that might (1) short-circuit our views concerning the past and the histories of technology and

media ecologies and (2) produce viable futures for novel concepts, paradigms, and formulations concerning media design. As I wrote in the prologue of Chapter 1, perhaps viruses might prove to be intellectual tools, too, with which to create new concepts in, and viewpoints on, digital culture and the cultural history of computing and technology in general. Hence, viruses can be taken not merely as the objects of this book, but as its copartners, presenting their logic of lively virality as a titillating way of doing cultural analysis: to move, to stutter, to repeat but with a difference.

Even though most of the media theory of networking and artificial life has focused on the 1980s and more recent decades, the early experiments in the 1950s and 1960s with networking capabilities had already introduced ideas and programming practices that challenged the traditional image of hierarchical systems. The computer pioneer John von Neumann was not only occupied with computers as brains; his later work provided the first theories of cellular self-reproducing automata, which have inspired mathematicians and computer scientists ever since. Less familiar are the experiments by Nils Barricelli at Princeton, where in 1953 he applied symbiogenesis to computers. Barricelli's computerized genesis thought gene interaction in terms of system abilities, not individuals, something that Ludwig von Bertalanffy had also suggested in the 1950s: study biology in terms of systems, not individuals. Quickly his ideas spread across a much wider social field than biology alone. As interesting as Barricelli's claims was Beatrice and Sydney Rome's Leviathan system a few years later. Leviathan was modeled as a computer environment, where the practical use was to analyze decision making. Yet, the implications for simulated computational ecologies went much further and would also merit additional research.

Experimental reproductive software became more than metaphors and was intimately connected to ways of creating new ideas that resonated with the then-popular topics of complex systems, nonlinearity, networks, and even chaos theory. Again, thinking in terms such as "ecology" is to be taken not as a mode of weak metaphorics, but as a way to grasp the interactional and network qualities of software. In this sense, I propose (following, for instance, Matthew Fuller) how the concept of media ecologies proved its worthiness. The network ecology is a media ecology not because of the terms used ("viruses", "worms", "bacteria", etc.) but because of the processes that rely on connectivity, networks, systems, and also becomings (the potential of indeterminacy within the systems).

Media ecological methods of analysis work by creating transversal connections between various spheres, or "ecologies" as Guattari calls them. For Guattari, media are "profoundly political or ethico-aesthetic at all scales."[6] Thought is a

(media) laboratory committed to experimentation, which follows the ethical stance of diversity. Aptly, Braidotti emphasizes that the task of critical theory is a continuous movement and articulation of these various spheres to account for the complexity of contemporary culture.[7] Guattari's *Three Ecologies* encompasses the spheres of the environment, social relations, and human subjectivity (mental ecology), which are all on the verge of an ecological crisis owing to the pressures and pollution induced by IWC, International World Capitalism. These three registers are made of economic, juridical, techno-scientific, and subjectifying semiotics. In my take, the media ecology of network culture traverses these three domains, and it, too, is forced to encounter the same pressures and processes of information capitalism. This theme is approached as one of both standardization (the commercialization of software and standardization of operating systems and software since the 1980s) and controlled complexity since the 1990s (the ability of the capitalist axiomatics to capture even the most diverse parts of digital culture as part of its flows of profit). In relation to such trends, Guattari's quest for "cultivating a dissensus"[8] and heterogenesis of network digital culture includes the need to diversify the mental ecologies in the sense of producing new images to think with concerning viruses and worms—and also the need to find new social relations not merely between people but between technologies, people, and nature.

Objects are interdependent and networked: worms and viruses are part of processual networks of media ecology, not self-sustaining but always dependent on other, symbolic and material, elements within the network to maintain their existence. Media ecologies are, then, parasitic and coupling by nature. The challenge is not to take any notion of a healthy cultural network without disturbances or noise as the starting point but to see elements of breakdown as part and parcel of those systems. Even if we are used to thinking of systems as harmonious, "in the beginning there was noise",[9] as Serres notes, emphasizing the priority we should give to the parasites that reveal the networks that otherwise go unnoticed: assemblages reveal their structurations and links only at the point of breaking down.[10] This should be seen also as an ecosophical stance toward valuing the accidental, the minoritarian, and the virtual: heterogenesis.

Foucault's archaeology's major contribution was, in resonance with this horizon of media ecological thinking, to point toward a more heterogeneous level of *savoir*—underlying, for instance, scientific disciplines—where scientific and nonscientific discourses interact.[11] For Foucault, archaeological analysis means also digging the overlapping, changing, and transversal lines of discourses and practices on which traditional historical analysis (of molar entities such as science and technology) rests. In the wake of such ecological analysis, media archaeology,

too, should be seen as transversal mappings of various heterogeneous lines, from fiction to science, from politics to theory, and from media to economics. These lines are the molecular lines of force (*puissance*) or levels of *savoir* that are fundamental to cultural analysis committed to complexity and temporality. Here also lies the need for further work within, for instance, the field of media archaeology, which needs to develop nonlinear approaches that take into account the specificity of technical media but that does not neglect discursive and incorporeal events.[12]

In other words, various heterogeneous lines traverse the media ecology of viral network culture: some lines aim at stagnating measures, others at deterritorializing movement toward experimentality.[13] As *Digital Contagions* has shown, the agenda does not assemble itself according to binary coordinates of security officials and antivirus researchers versus the hackers and virus writers. Instead, we have a multiplicity of actors who design and define the digital culture and its software. To further complexify the issue, my take on ecology works also toward temporal layering and the media archaeology of the virus phenomenon. The ecology of network culture is layered just as layering is used as a design technique in multimedia production (the layering of design modules) or in archaeology, where layers can be seen as soil material that stores or preserves traces of cultures past. The image of a layer as a conceptual tool demonstrates how objects are always temporally condensed, stratified, and overdetermined. The layers are not, however, homogeneous self-sufficient strata but continuously open up toward other layers, having links in various time coordinates and durations. They are constituted of phylogenetic lines (of various durations) and of ontogenetic lines, which cross transversally between assemblages.[14]

Different types of rhythms, variations, and durations coexist in a temporal tension. The so-called present is always a tension between various temporalities, where every actuality collects together movements of different rhythms.[15] Similarly, software objects and media technological assemblages are layered in time, which calls for an agenda of historical media archaeology. As I started the book with Virilio's plea for a specific interest of knowledge in accidents of media technologies, now I want further to emphasize the temporal tensions and durations such an agenda has, connecting it to the politics of cultural memory. Such a focus on cultural analysis takes the historical, the archaeological into its core.[16]

Of course, as noted throughout the book, computer worms and viruses are not merely accidents (of the Aristotelian substance) but span more deeply into the logic of network capitalism and artificial life, for instance. Yet, the idea and concept of accident can be taken here, as proposed above, as a good tool for thought. The apocalyptic tones in digital accidents can be understood, to

follow Charlie Gere, via their Greek etymology in *apo-kalyptein*, a revealing of the (discourse networks) otherwise concealed.[17] Machines reveal their logic as they break down, and this state of accidentality bears in itself important epistemological and ontological repercussions. Gere also refers to Walter Benjamin's concept of history where the time of the revolution, of the breaking down of everyday rhythms, has a special political value. In his "Theses on the Philosophy of History", Benjamin conceptualizes the stopping of clocks on the first night of the French Revolution as the creation of a novel temporal duration.[18] The homogeneous time of clocks was replaced with a halt, a pause, that promised an opening of a potentiality. Benjamin can in many respects be considered the first media archaeologist in his emphasis on temporal analysis as a critical constellation that can be short-circuited as part of the present to inflict cracks and discontinuities. This is a stereographic view of historical research where the image of the past is made dimensional in connection with the image of the present—a synthetic conjoining.[19] Benjamin, born in the age of new optical technologies, wrote about stereographical images; we could, in a parallel fashion, write about digital image processing and animation technologies, part and parcel of the cultural techniques of contemporary media culture. These are synthetic devices to think with in their capability to overlayer, integrate, merge, and recreate new series from old material. It is a question of how and with what media technological tools to think with we sketch temporal layers, historical paths, and archaeological events.

Apocalypses reveal new temporalities, new layers for a media archaeology of the present. This means a move from the time of Chronos as one of imposed linearity that homogenizes the past and the future toward the registers of Aion and Kairos. Aion means for us the time of the nonhuman duration, the rhythms of the technological being, the nonrepresentable becomings on the level of computer software, for example. Kairos, on the other hand, is the time of the political: to know how to act in the right moment, and to create new temporalities, cuts in the repetitious nature of Chronos.[20]

Gere connects this to the thematics of network capitalism, where computers (also temporal machines) function as machines of ordering, control, and communication. Where Gere refers to the figure of the hacker as an interruption in these processes, we can also refer to viruses and other accidents as key processes of revealing of the homogeneity that threatens this media ecology. Of course, cancerous growth eats itself, but at the same time there is the possibility to look at the history and future of digital culture through the lens of its accidents and to affirm novel ideas in experimental programming, nonlinear systems, and conceptual becomings concerning virality, media ecology, and temporal layerings of the

archaeology of media cultures. This is what I referred to as the task of creating a minoritarian cultural memory of the digital culture, which dislodges established notions of technological culture of networking and works toward nomadic becomings—on a conceptual and on a practical level. This is an ecosophy of sorts, working within the ecology of digital culture: ecosophy as a mode of bringing forth multiplicities and diversities.

The real task, then, is a transformation of ecological thinking into ecosophy. This book has proceeded as a mapping, or as a cartography of sorts, but one that has tried not only to trace "what happened." It has also tried to look for affirmative potential in an archaeology of viral programs. Archaeology is something that is not about the past alone; it has the potential to stretch toward a future. Media ecological analysis has in this sense the advantage, perhaps to some a paradoxical one, of steering clear of naturalizing histories of media into timeless "matters of fact." As shown above, media ecology can work toward a concept of nature that would take advantage of Spinoza's notion of *natura naturans*: nature is not merely a collection of law-abiding repetitive patterns (whether we talk about the biological nature or the digital media ecology). Instead, nature works against itself, is self-differing. Media ecology, which strives to see how issues technical relate to politics, economics, aesthetics, and history, is in this sense not to be removed from the ecosophical task of cultivating the potential for a difference. Technicalities do not translate directly into politics, but only via mediations, and cultural analysis that does not steer away from complexities but cultivates them might just be in a key position to carry out such a task of translation and transformation.

Notes

1. Nori 2002. See also Michelle Delio: "The Beauty and Grace of a Worm." *Wired*, May 22, 2002. <http://www.wired.com/news/culture/0,1284,52687,00.html>.

2. In this contextual focus on assemblages I am following Sampson 2008.

3. Spinoza 2001, 58 (II, Axiom I, Lemma I). Deleuze 1986, 39–40.

4. Guattari 1995, 37.

5. See Deleuze 1997b.

6. Ibid., 5. On mediasophy, see Väliaho 2003.

7. Braidotti 2006, 127.

8. Guattari 2000, 50. For views on "software criticism", see Fuller 2003. See also Lovink 2003.

9. Serres 1982, 13.

10. See Heidegger 1996, §16. Deleuze & Guattari 1983, 8. Lundemo 2003.

11. Gutting 1989, 253.

12. Cf. Ernst 2006.

13. Deleuze (1992, 164–165) writes of the apparatus (*dispositif*) consisting of two types of lines: lines of stratification and lines of creativity, of flight. Here I partially depart from Deleuze's emphasis: for me, history and archives are not merely the static past but can be articulated as essentially resonating with lines of creativity of a future. Benjamin, on the other hand, then, gives a more positive understanding of the powers of the past as forming critical constellations. See Buck-Morss 1991, 289–293. For a fresh analysis on the question of history in Deleuze and Guattari's thought, see Lampert 2006.

14. See DeLanda 1991, 140. Cf. Zielinski's (2006) notion of media archaeological layers and the task of an-archaeology of the deep time of the media.

15. Braudel 1997, 205.

16. On cultural analysis, see Bal 1999, 1, 12–14.

17. Gere 2002, 9.

18. Benjamin 1969, 261–263. Gere 2002, 195–196. Virilio, in particular, sees contemporary technological accidents in terms of temporality. See Redhead 2004.

19. See Buck-Morss 1991, 289–293.

20. Zielinski 2006, 28–32.

A Timeline of Computer Viruses and the Viral Assemblage

This timeline is intended as a heuristic tool-for-thought that places various events and contexts together on a continuous timeline. It is not an exhaustive archive of all the important dates but gives an overview of the development of viruses and related phenomena. The information has been gathered from a number of sources mentioned in the Bibliography. The estimated numbers of PC viruses are from F-Secure statistics.

1872	Samuel Butler discusses the fear of technology becoming self-reproductive in his novel *Erewhon*.
1936	Alan Turing develops his ideas of a so-called Turing machine that is able to simulate any other machine.
1948	C.E. Shannon formulates his mathematical theory of communication, where he includes noise as part of the communicative act.
1949	John von Neumann lectures on "The Theory and Organization of Complicated Automata."
1950s	Biological virology is established as a key research area.
1953	Nils Barricelli's experiments with ideas of symbiogenesis are applied to computers at the Princeton Institute of Advanced Studies.
1958	The principles of the modem for computer communication are established.
1959	Beatrice and Sydney Rome's experiment on a "Leviathan-computer system" based on adaptability.
1961	Darwin, a game where digital organisms fought for memory space, is developed at the Bell Labs (a precursor of Core Wars, see year 1984). The second edition of Wiener's *Cybernetics* (orig. 1948) is published, where he discusses self-reproducing machines.
1964	Paul Baran's key paper "On Distributed Communications" is published.
1966	Michael Apter discusses self-reproductive organisms in his *Cybernetics and Development*. Von Neumann's *Theory of Self-Reproducing Automata* is edited and posthumously published by Arthur W. Burks.