From 99% to 99%

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This work analyzes how the world's computer network changed in a 15-year period, from 1977 to 1992. In 1977, 99 percent of the world's computing power resided on mainframes. By 1992, the percentages had flipped: 99 percent of computing power sat collectively on the world's desktop and laptop computers. [1]

At a certain moment in time, between 1977 and 1992, the world's computer network 'exploded', shifting from total concentration into complete dispersion. This shift from one intensity to another brought along new space-time relationships altering our social networks and their ordering principles. By doing so, it defined a new landscape. In picturing it, this paper will map out the above-mentioned shift by analyzing the following aspects of each of these moments in time:

- Time Attributes or how geographically located computer-time, back in the 70's, has been converted into ubiquitous computer-time by contemporary computer networks.
- Spatial Qualities or how geometric layout design, as the main concern when designing computer networks, made its way for connection bandwidth, or speed connection capability, as the main concern when using computer networks.
- Social Networks or how a cross section of a connection between computer network nodes, instead of a plan defining their exact position, can better describe contemporary social networks.
- Control Tactics or how regulating has necessarily been given priority over organizing as the main ordering social principle.

We simultaneously inhabit different landscapes. Although each of them shows specific and distinct characteristics, they influence each other to the point at which our medium cannot be clearly defined with a unique set of parameters. Our medium is defined, in fact, by the local relationships occurring between these landscapes at any specific location and at any given moment. The world's computer network has now been commonly accepted and constitutes a new landscape definitively added to our environment. For this reason, our everyday life is to some extent influenced—in some places more than in others and some times more than others—by the structural qualities defined by this network. As previously mentioned, its influence will be rendered visible by the analyses of four different aspects: Time Attributes, Spatial Qualities, Social Networks, and Control Tactics.

TIME ATTRIBUTES

From Time Slots to Time Vectors

On June 27th 1962, Ross Perot founded Electronic Data Systems (EDS).

> "EDS began by doing business on other people's computers. From the start, the company's vision was not to make computers but to help customers get the most out of them. Without computers of its own, EDS first processed customers' data by using other companies' mainframes, which often sat idle during the middle of the night. By exploiting that excess capacity, EDS put tremendous computing power within the reach of clients whom otherwise could not afford it." [2]

Even though in 1965 EDS acquired its first computer, an IBM 1401, the company continued renting time on other companies' mainframes until the late 60's. This was done with employees filling up "[...] their car trunks with forms, computer tapes and programs, frequently driving to different locations to process work in the middle of the night." 3 Each employer, therefore, would take with him the exact amount of information that could be processed in the slot of time that he had been allocated. It is evident, nevertheless, that this amount of information would very rarely coincide with the whole amount of work to be done for a certain job. For this reason, packages of information—personalizing EDS's employers—would travel through the Interstate Highway System for being processed on different mainframes. Back at EDS's headquarters, and before it was delivered to the client, the different information packages would have to be organized into their original order. This way of managing information by fragmenting it into packages can be perceived as a precedent of how contemporary computer networks work.

Paul Baran, researcher at RAND Corporation in the 1960's, conceived the ARPANET's [4] layout design and its communication system so it would continue to function under any kind of attack. [5] In doing so, he established the foundations for the communication system of contemporary computer networks. Oddly enough, this communication system uses an identical information management strategy as the one used by EDS. "By dividing each message into parts, you could flood the network with what he called"'message blocks', all racing over different paths to their destination. Upon their arrival, a receiving computer would reassemble the message bits into readable form." [6]

It is very interesting to note that ARPANET and the Interstate Highway System were conceived at the same moment in time and designed following the same principles. [7]

> "In 1957, while responding to the threat of the Soviets in general and the success of Sputnik in particular, President Dwight Eisenhower created both the Interstate Highway System and the Advanced Research Projects Agency, or ARPA. One project sponsored by ARPA was a network of computers that could interact with each other, even though they were not manufactured by the same company. Further, this network must be capable of surviving a nuclear attack and still function in an effective manner." [8]

For this, EDS's information management operations—a distribution of employers traveling in a distributed highway system—can be regarded as the 'real' version of Paul Baran's 'virtual' communication network—distributed information packages traveling in a distributed computer network. It is necessary to note that both versions happened at the same moment in time when 99 percent of the world's computing power still resided on mainframes.

In very simple terms, Ross Perot's company was merely renting slots of computer-time—as we all know, "Time is money". But this computer-time is a synchronous one. The user's presence is essential for the system to work: the user has to be present at the right moment for being able to make profit out of the slot of time. For this reason, these vacant slots of computer-time could be understood as a Real Estate value in a computer-time geography—in a similar way to how vacant lots are considered Real Estate values in a spatial geography.

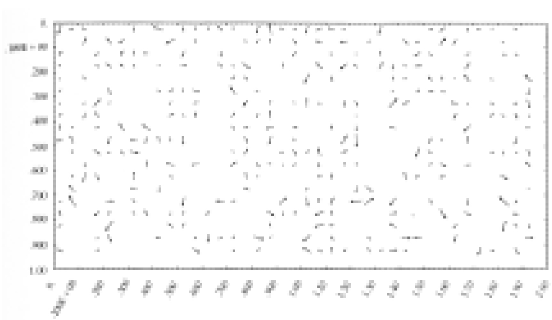
> "[...] There are important differences between the way people talk to each other

Interstate Highway System.

Walter Gropius, Diagrams of the various possibilities of subdivision of an area of rectangular shape destined for building construction. [9]

> and the way computer converse. In a telephone conversation, people tend to talk continuously, or even both at once. For that reason, the electronic link between them is reserved exclusively for them and remains open for as long as they wish to speak. Computer conversation, on the other hand, is a rather more staccato affair. [...] Information is bundled up into discrete packages and a line is held open just long enough for the package to be sent. Once the message has been received, the connection is closed and the message can be digested 'off-line'." [10]

Molecular chaos. [11]



In 1992, when the percentages reversed, computer networks had already established a non-synchronous reliable communication system. For this, the geography of computer-time was transformed from a series of vacant and occupiable slots of computer-time into a series of computer-time vectors that measured how fast information could reach its destination. However, and although this communication system is a non-synchronous one, time is still money. But in this case, money is no longer a vacant and occupiable slot: money is now a vector that can be located in the cross section of a computer network cable. The new computer-time is a portion of the connection bandwidth between computers.

SPATIAL QUALITIES

From Geometric Layout to Bandwidth

The shift that is being mapped out in this work can also be perceived in the main spatial aspects of both computer networks: geometric layout was ARPANET's most essential aspect, back in 1977, while connection bandwidth began to be the most important aspect of any computer network designed from the 90's onwards.

In 1969, when the first two computers were connected, it was already clear what kind of computer network ARPANET should be. Not only because of Paul Baran's—now very famous—memorandum RAND RM-3420-PR written in 1964, On Distributed Communications, but also because there had already been an interest—back at the times of the Second World War—in knowing which would be the organizational network model with the highest probabilities of surviving an attack. As a matter of fact, RAND Corporation had been set up in 1946 to preserve the nation's operations research capability developed during World War II. [12]

Among the several infrastructures that were considered vulnerable, the telecommunications network was found to be a very sensitive one. The United States' telephone network was, at the time, centralized in Omaha: a popular place for long-distance telephone switches just because it lay at the nation's geographic center.

> "At the time, the nation's long-distance communications networks were indeed extremely vulnerable and unable to withstand a nuclear attack. Yet the president's ability to call for, or call off, the launch of American missiles (called 'minimal essential communication'), relied heavily on the nation's vulnerable communications systems. So Baran felt that working on the problem of building a more stable communications infrastructure—namely a tougher, more robust network—was the most important work he could be doing." [13]

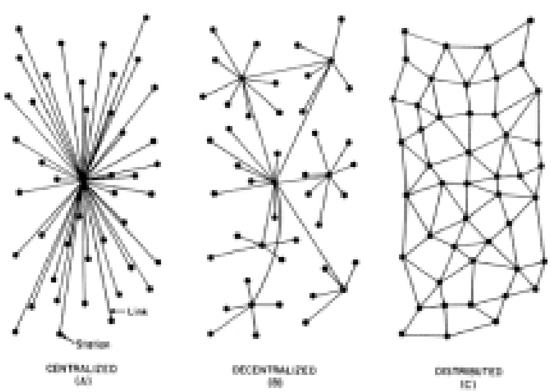
Baran's search for the most stable network was a very broad-minded one. It was not only based on mathematical models and computer simulations but it also included discussions with other fields' scholars, including Warren McCulloch—an eminent psychiatrist at MIT's Research Laboratory of Electronics.

> "Baran was working on the problem of how to build communications structures whose

> surviving components could continue to function as a cohesive entity after other pieces were destroyed. [...]"'Well, gee, you know,' Baran remembered thinking, 'the brain seems to have some of the properties that one would need for real stability'. It struck him as significant that brain functions didn't rely on a single, unique, dedicated set of cells. This is why damaged cells can be bypassed as neural nets re-create themselves over new pathways in the brain." 14

One of the key issues for economically designing such a stable network is knowing how many links between nodes are needed. For the network to be as inexpensive as possible, the fewer links between nodes, the better. But the fewer links, the less resistant the network would be to an eventual attack. Finding the right number of links—Baran called this 'redundancy level'—was therefore the key question. After numerous tests and simula-

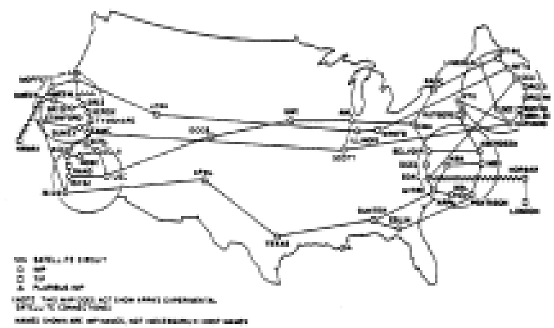
"This Memorandum briefly reviews the distributed communications network concept and compares it to the hierarchical or more centralized systems. The payoff in terms of survivability for a distributed configuration in the cases of enemy attacks directed against nodes, links, or combinations of nodes and links is demonstrated.""[16]



tions, Baran —"concluded that a redundancy level as low as 3 or 4—each node connecting to three or four other nodes—would provide an exceptionally high level of ruggedness and reliability." 15

Therefore, in 1977, the ARPANET was defined by its layout. To have access to the network became the key issue. Therefore, the location of the network nodes was an important decision not only to

Map of the ARPANET on July 15th 1977.[18]



survive an eventual attack, but also for providing access to as many users as possible.[17]

At this point, when it was realized how the network layout should be, the connection between different computers began to be the key issue. This was finally possible because of the Transmission Control protocol (TCP/IP). This communications protocol ensured communications between computers manufactured by different companies. In 1984, the U.S. Department of Defense made TCP/IP the standard communications protocol for all military computer networking, which gave it a high profile and stable funding. For this reason, TCP/IP gained advantage over other networking possibilities and was finally established as the main protocol to connect computers. It is the protocol that our computers still use nowadays. The importance of being networked started to increase.[19]

> "With the development of hypertext systems and networks, the Web had two of its principal ingredients, but there was a third. What allowed the Web to grow so quickly was personal computing."[20]

At a certain moment in time, between 1977 and 1992 and due to the high increase of personal computing, the computer's world network, explodes, dissolutes and vanishes. From this moment onwards the Internet's layout is no longer its definitory aspect: its spread grade is so high that it has surpassed the critical level above which geometric layout becomes unimportant. For these reasons, in 1992 the network is vast enough to be accessed from almost anywhere. In these conditions, what defines the computer network is its connection bandwidth, that is, its speed connection capability—its ability to connect two points at the highest speed. The size of the files is no longer important: what is determinant is the time that is needed to send that file—as it can be seen in the latest version of Adobe Photoshop.

Saving JPEG dialog from Adobe Photoshop v. 7.0.

If designing the network was the 60's action, using it became the 90's need. The new social trend consists in being connected. [21]

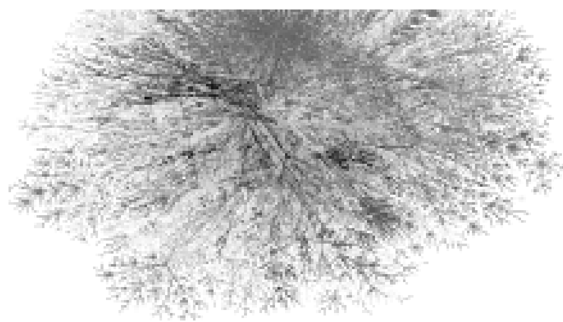
SOCIAL NETWORKS

From Plan to Cross Section

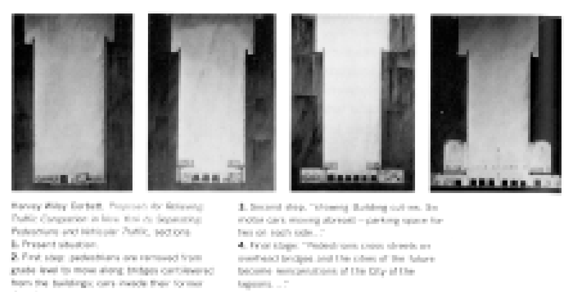
As explained, the shift of computer power, from mainframes to desktop and laptop computers, had a main spatial consequence: computer networks' wide spread around the world made it possible to access the network from practically anywhere. As it has also been explained, this change in the location of the world's computer power claimed for speed connection capability once the network's ubiquitous access had been guaranteed. It seems evident: first comes the pipe, then the water volume.

Any infrastructure is defined following those same steps. In its first phase of design, the network's layout is developed through plan. The plan, through a totalizing geometric pattern, allows for complete control. In a subsequent phase, the infrastructure's users claim for progressive adjustments in its cross section. The time for localities has arrived: social attributes define, according to local specificities, the quality of the network's cross section. Through the progressive definition of its section, the network allows for a more local and specific design.

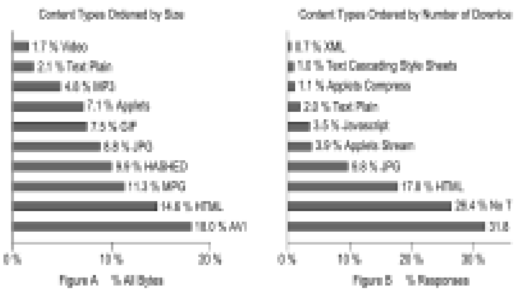
Map of the Internet published on Wired Magazine's issue of December 1998. [22]



This process can be very clearly perceived in Rem Koolhaas's Delirious New York. [23] Once the grid—as the generic geometric layout for the whole island—was established, studies, according to specific local conditions, were progressively conducted for the definition of its cross section.



The department of Computer Science & Engineering at the University of Washington has conducted several studies to try to understand their computer network's behavior. As it can be seen from the following chart, the most requested items are not the ones that hold the highest percentage of the network's resources usage. On the contrary, items that are requested by a small part of the University of Washington's community occupy the biggest portion of the bandwidth. It is no longer a question of geometrically organizing the position of each node. The actual priority for any networked community is to regulate their network's resources according to local needs—if not, local needs will affect the totality of the community due to a poor management of the network's resources. This contemporary needed management implies new techniques for organizing its computer networks' cross section.



Figures A and B show the top 10 content types requested by University of Washington clients, ordered by bytes downloaded and number of downloads. While GIF and JPEG images account for 41.6% of requests, they account for only 16.3% of the bytes transferred. On the other hand, AVI and MPG videos, which account for 29.3% of the bytes transferred, constitute only 0.41% of requests. [24]

CONTROL TACTICS

From Gardeners to Gamekeepers

Zygmunt Bauman, when analyzing the emergence of modernity, explains—quoting Ernest Gellner—how —"wild cultures reproduce themselves from generation to generation without conscious design, supervision, surveillance or special nutrition." [25] Cultivated or garden cultures, on the contrary, can only be sustained by literary and specialized personnel. [26] The garden has to be perceived as a very fragile organizational system where supervision and surveillance is constantly needed in order to keep the imposed delicate order clean from weeds and other uninvited plants. John Urry, in his book Sociology beyond Societies, explains how an inverse shift—following the opposite path to the one described by Bauman—is currently taking place. 'National' forces must now see themselves as regulatory forces rather than as organizing forces: "The concept of society will in the future be one particularly deployed by especially powerful 'national' forces seeking to moderate, control and regulate these variously powerful networks and flows crossing their porous borders." [27] As he continues to explain, there should be a return to the gamekeeper state: 'national' forces should only be concerned with regulating mobilities.''National' forces should realize that total control, as it was understood, is no longer possible.

> "Such a gamekeeper state was not bothered to give society an overall shape and was uninterested in detail. By contrast the gardening state presumes exceptional concern with pattern, regularity and ordering, with what is growing and what should be weeded out. [...] The new global order involves a return to the gamekeeper state and away from that of the gardener. The gamekeeper was concerned with regulating mobilities, with ensuring that there was sufficient stock for hunting in a particular site but not with the detailed cultivation of each animal in each particular place." [28]

This shift, from gamekeeper states to garden states, is analogous to the one described, and widely studied, by Deleuze and Guattari: from disciplinary societies to societies of control. In summary, it could be said that disciplinary control has been overwhelmed by contemporary mobilities. Disciplinary control believes in an ideal state—such a state has a unique equilibrium point that is constantly pursued by its gardeners through supervision and surveillance—but disciplinary control cannot organize mobilities—they are out of its reach. Dynamical systems based on mobilities do not have a unique state of equilibrium: they have multiple. Therefore, gardening techniques are no longer useful.

> "More generally, Deleuze and Guattari suggest that there has been a recent shift in western societies away from social relations based upon territory and state—that is, Foucault's disciplinary societies. The move is to societies of control, to social relations based upon numbers and deterritorialisation. Contemporary states are forced to regulate 'the mobile occupant, the movable in smooth space, as opposed to the immovable in striated space' (Gilles Deleuze and Felix Guattari, Nomadology, Semiotext(e), New York 1986,

> p. 66). Such smooth deterritorialised spaces, of which the pure number is the paradigm case, creates huge new issues for states. Such flows are smooth and deterritorialised especially because of computerized digitization: 'what counts is not the barrier but the computer that tracks each person's position' (Nigel Thrift, Spatial Formations, Sage, London 1996, p. 291)." [29]

Computer networks' control techniques have recently undergone a similar shift. A computer network should be understood as a communication system that makes certain informational resources available. Since the bandwidth that connects computers has a limited capacity, the availability of the hypothetical available resources varies depending on how the computers connected to the network behave. Traditionally, computer networks have been seen as gardens, being its network administrator the organizer of the system—that is, performing the tasks of the gardener by controlling the available bandwidth of the network. Recently, and due to the new and abusive use of Peer to Peer (p2p) applications, a new kind of control needs to be implemented since these new applications continuously demand, due to its competitive nature, the broadest bandwidth possible—as it can be realized from University of Washington's previously shown study charts. For this reason, the network administrator can no longer control how the resources of the network are managed: his abilities, those of the gardener, are overwhelmed by the continuous, mobile and high demand of these new users. Therefore, new control techniques, such as Package Shaper consisting mainly on an individualized regulating mechanism for each networked computer, are being implemented. Its working mechanism is very simple: it works as a tap with a limited opening—MTU or maximum size of acceptable package.

This new kind of control exemplifies the abovementioned shift argumented by John Urry: from organizing forces to regulatory forces. Computer networks cannot longer be perceived as a garden to be constantly supervised and guided towards its optimal and ideal state. Instead, they should be understood as a gamekeeper state and, therefore, new control techniques based on individualized regulatory systems must be developed.

The map shows Haarlemmermeer's area water leveling system before the definitive drainage of the whole area in the XIX century—around 1850's. Interrelated and individually regulated water locks integrate Holland's system of floodgates: a clear example of a gamekeeper state where multiple states of equilibrium are possible.

PLANNING ... AND GETTING LOCKED-IN

The landscape of the world's computer network—as it has been mapped out in this work—was, and still is, being shaped by a combination of several conditions. Among these, some aspects were planned—for instance, its geometric layout design—but some others were not—for instance, the TCP/IP communications protocol. In any case, it has to be understood that the final outcome—the world's computer network as we can see it today—has two main qualities. First, it is not—it was not—the best option of the many that were possible. This landscape could have ended up somehow differently, even being a more efficient one. The design of this landscape has never been under total control: randomness has also decided. Second, it will not change: technological landscapes cannot be reshaped. Once they select a particular path they usually become locked-in. This landscape will just be taken over by newer ones—and it will coexist with them.

The reason for these is that the landscape of the world's computer network is managed by a positive feedback system—as many other infrastructural landscapes that we can think of. This system is also known as increasing returns. 30 In this kind of systems, "tiny perturbations won't always remain tiny. Under the right circumstances, the slightest uncertainty can grow until the system's future becomes utterly unpredictable—or in a word, chaotic." [31] Brian Arthur, explaining how economy is ruled by a positive feedback system, is in reality describing the process that is followed by any market in its settling process.

> "Diminishing returns imply a single equilibrium point for the economy, but positive feedback—increasing returns—makes for many possible equilibrium points. There is no guarantee that the particular economic outcome selected from among the many alternatives will be the—'best' one. Furthermore, once random economic events select a particular path, the choice may become locked-in regardless of the advantages of the alternatives." [32]

In summary, the shift from one intensity to another—from one 99% to another 99%—implied certain intrinsic processes that, along with other planned wills, have shaped the landscape of our current world's computer network. The fact that we are locked within this unchangeable landscape shall not be seen as a disadvantage: it should rather be regarded as the circumstance that allows us to calmly perceive and analyze the influences that such a landscape is inflecting upon us. This analysis is of utmost importance: we cannot redefine the landscape but we can still influence how it locally relates to other landscapes we inhabit. But before we are able to influence it, we need to know how this landscape is influencing us.

NOTES

[1] From a message by Rich Karlgaard, editor of Forbes ASAP, posted in the WWW by David J. Farber—The Alfred Fitler Moore Professor of Telecommunication Systems in the School of Engineering and Applied Sciences and a Professor of Business and Public Policy at the Wharton School, University of Pennsylvania. *NAFTA's Strange Bedfellows: It's Only the Beginning,* http://lists.elistx.com/archives/interesting-people/199311/msg00075.html.

[2] *EDS through the years*, http://www.eds.com/about_eds/about_eds_history_timeline.shtml.

[3] Ibid.

[4] ARPANET, the computer network for the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense, was created in 1969 and shut down in 1990. Due to its pioneering nature it has to be regarded as the predecessor of the Internet.

[5] Lately—but also for the same reasons—this system has been proved to be an extremely effective way of avoiding traffic congestion.

[6] Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York: Simon & Schuster, 1996), pp. 59-60.

[7] In fact, Al Gore, as it is explained in *History of Internet and WWW*, became in the 90's the'point man in the Clinton administration's effort to build a *national information highway* much as his father, former Senator Albert Gore, was a principal architect of the Interstate Highway System a generation or more earlier.

[8] *Systematic Testing of WWW Applications*, http://www.oclc.org/webart/paper2/#references.

[9] Studies realized in 1935. Walter Gropius, *Die neue Architektur und das Bauhaus* (Berlin: Mann, 2003), ill. 23.

[10] James Gillies and Robert Cailliau, *How the Web was Born: The Story of the World Wide Web* (New York: Oxford University Press, 2000), p. 1.

[11] Gregorie Nicolis and Ilya Prigogine, *Exploring Complexity: An Introduction* (New York: W. H. Freeman and Company, 1989), p. 7.

[12] Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York: Simon & Schuster, 1996), p. 55.

[13] Ibid.

[14] Ibid. pp. 56-57.

[15] Ibid. p. 59. However, due to departmental reorganization—and some bureaucratic impediments—Baran's studies were not considered until 1968 when they were retrieved for ARPANET's design. But oddly enough, this redundancy level is exactly the same one that was being used in the design of the Interstate Highway System. As it can be seen in the map previously shown, most American cities are connected to three or four other cities, conforming all of them, a very reliable highway network.

[16] Paul Baran, "On Distributed Communications: I. Introduction to Distributed Communications Network,""*RAND Corporation memorandum* RM-3420-PR (August 1964).

[17] Some facts extracted from

CHM: Computer History Online Exhibits can demonstrate the authorities' willingness for building up a broad and rich computer network:

- As early as in 1968, the ILLIAC IV, the largest supercomputer of its time built for NASA, was hooked to the ARPANET "so that remote scientists could have access to its unique capabilities".

- In 1974,"[...] the National Science Foundation (NSF) is actively supporting computing and networking at almost 120 universities".
- And in 1984, "the British JANET explicitly announces its intention to serve the nation's higher education community, regardless of discipline. Most important for the Internet, NSF issues a request for proposals to establish supercomputer centers that will provide access to the entire U.S. research community, regardless of discipline and location".

[18] *ARPANET Maps*, http://som.csudh.edu/cis/lpress/history/arpamaps/f15july1977.jpg.

[19] This fact can be easily perceived in the study-case of the John Von Neumann Supercomputer Center at Princeton University. The supercomputer needed to be connected to as many other personal computers as possible—for as many researchers to take advantage of it as possible. But this network also allowed scientists to be connected between them. When the funding for the supercomputer ended, efforts were made to maintain the network: it could be said that it had gotten a life of its own.

[20] James Gillies and Robert Cailliau, *How the Web was Born: The Story of the World Wide Web* (New York: Oxford University Press, 2000), p. 115.

[21] Koyi Kobayashi, former Chairman of NEC Corporation (NEC), has studied the evolution of the computer in relation to its communications. Computers and communications (C&C), according to his point of view, cannot be understood independently one from each other. See Koji Kobayashi, *Computers and Communications* (Cambridge: The MIT Press, 1986).

[22] Generated from data collected in mid-September 1998. *Internet Mapping Project*, http://research.lumeta.com/ches/map/index.html.

[23] Rem Koolhaas, *Delirious New York: A Retroactive Manifesto for Manhattan* (New York: Oxford University Press, 1978), p. 122.

[24] Department of Computer Science & Engineering at the University of Washington,

"An Analysis of Internet Content Delivery Systems," in *Proceedings of the 5th Symposium on Operating Systems Design and Implementation* (Boston: OSDI 2002).

[25] Ernest Gellner, *Nations and Nationalism* (Oxford: Basil Blackwell, 1983), p. 50.

[26] Zygmunt Bauman, *Legislators and Interpreters: On Modernity, Post-modernity and Intellectuals* (Ithaca: Cornell University Press, 1987), p. 51.

[27] John Urry, *Sociology beyond Societies: Mobilities for the twenty-first century* (London: Routledge, 2000), p. 1.

[28] Ibid. pp. 188-189.

[29] Ibid. p. 196.

[30] W. Brian Arthur,

"Positive Feedbacks in the Economy,""*Scientific American* 262 (February 1990), p. 92.

[31] Mitchell Waldrop,

Complexity: The Emerging Science at the Edge of Order and Chaos (New York: Simon & Schuster, 1992), p. 66.

[32] W. Brian Arthur, "Positive Feedbacks in the Economy,""*Scientific American* 262 (February 1990), pp. 92-93.

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· Stefan Saroiu, Krishna P. Gummadi, Richard J. Dunn, Steven D. Gribble, and Henry M. Levy, "An Analysis of Internet Content Delivery Systems," in *Proceedings of the 5th Symposium on Operating Systems Design and Implementation* (Boston: OSDI 2002). Available online at http://www.cs.washington.edu/research/networking/websys/pubs/osdi_2002/osdi.html.

· John Urry, *Sociology beyond Societies: Mobilities for the twenty-first century* (London: Routledge, 2000).

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Fig. 9A and 9B: Stefan Saroiu, Krishna P. Gummadi, Richard J. Dunn, Steven D. Gribble, and Henry M. Levy.

Fig. 10: Museum De Cruquius, Cruquius.

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