# 1

# Physical Media

The language of the RFC was warm and welcoming.
—KATIE HAFNER AND MATTHEW LYON, *Where Wizards Stay Up Late*

While many have debated the origins of the Internet, it's clear that in many ways it was built to withstand nuclear attack. The Net was designed as a solution to the vulnerability of the military's centralized system of command and control during the late 1950s and beyond. For, the argument goes, if there are no central command centers, then there can be no central targets and overall damage is reduced.

If one can consider nuclear attack as the most highly energetic, dominating, and centralized force that one knows—an archetype of the modern era—then the Net is at once the solution to and inversion of this massive material threat, for it is precisely noncentralized, nondominating, and nonhostile.

The term *protocol* is most known today in its military context, as a method of correct behavior under a given chain of command. On the Internet, the meaning of protocol is slightly different. In fact, the reason why the Internet would withstand nuclear attack is precisely because its internal protocols are the enemy of bureaucracy, of rigid hierarchy, and of centralization. As I show in this chapter, the material substrate of network protocols is highly flexible, distributed, and resistive of hierarchy.

The packet-switching technologies behind the Internet provided a very different "solution" to nuclear attack than did common military protocol during the Cold War. For example, in 1958 the Royal Canadian Air Force and the U.S. Air Force entered into agreement under the North American Aerospace Defense Command (NORAD). NORAD is a radar surveillance system ringing North America that provides early warnings of missile or other air attacks against Canada and the United States. "The command monitors any potential aerospace threat to the two nations, provides warning and assessment of that threat for the two governments, and responds defensively to any aircraft or cruise missile threatening North American airspace."[1] The NORAD system is a centralized, hierarchical network. It contains regional control sectors, all of which are ultimately controlled by the USSPACECOM Command Center at Cheyenne Mountain in Colorado Springs, Colorado. It functions like a wall, not like a meshwork. Faced with a nuclear attack,

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Epigraph: Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York: Touchstone, 1996), p. 144.

1. *NORAD: Into the 21st Century,* U.S. Government Printing Office (1997-574-974).

NORAD meets force with force. Once the outer protection zone of the landmass is compromised, the NORAD command is able to scramble defensive air power through a rigidly defined system of command and control that is directed outward from a single source (USSPACECOM), to subservient endpoint installations that help resist attack. The specific location of each radar installation is crucial, as is the path of the chain of command. During the Cold War, NORAD was the lynchpin of nuclear defense in North America. It is a "solution" to the nuclear threat.

The Internet system could not be more different. It follows a contrary organizational design. The Internet is based not on directionality nor on toughness, but on flexibility and adaptability. Normal military protocol serves to hierarchize, to prioritize, while the newer network protocols of the Internet serve to *distribute.*

In this chapter I describe exactly what distribution means, and how protocol works in this new terrain of the distributed network.[2] I attempt to show that protocol is not by nature horizontal or vertical, but that protocol is an algorithm, *a proscription for structure* whose form of appearance may be any number of different diagrams or shapes.

The simplest network diagram is the centralized network (see figure 1.1). Centralized networks are hierarchical. They operate with a single authoritative hub. Each radial node, or branch of the hierarchy, is subordinate to the central hub. All activity travels from center to periphery. No peripheral node is connected to any other node. Centralized networks may have more than one branch extending out from the center, but at each level of the hierarchy power is wielded by the top over the bottom.

2. The division of network designs into centralized, decentralized, and distributed appears in Paul Baran's *On Distributed Communications: 1. Introduction to Distributed Communications Networks* (Santa Monica, CA: RAND, 1964), p. 2. Baran's diagrams have been copied by many authors since then.

Following William Evan, John Arquilla and David Ronfeldt suggest a topology even simpler than the centralized network. This is the chain or line network: for example, "in a smuggling chain where people, goods, or information move along a line of separate contacts, and where end-to-end communication must travel through the intermediate nodes." See Arquilla and Ronfeldt, *Networks and Netwars: The Future of Terror, Crime, and Militancy* (Santa Monica, CA: RAND, 2001), p. 7.



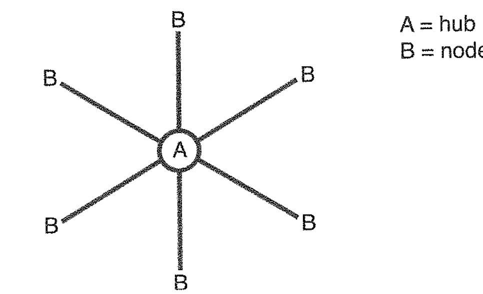


Figure 1.1
A centralized network

The American judicial system, for example, is a centralized network. While there are many levels to the court system, each with its own jurisdiction, each decision of each court can always be escalated (through the appeals process) to a higher level in the hierarchy. Ultimately, however, the Supreme Court has final say over all matters of law.

The panopticon, described in Foucault's *Discipline and Punish,* is also a centralized network. In the panopticon, repurposed by Foucault from the writings of Jeremy Bentham, a guard is situated at the center of many radial cells. Each cell contains a prisoner. This special relationship between guard and prisoner "links the centre and periphery." In it, "power is exercised without division, according to a continuous hierarchical figure" occupying the central hub.[3]

A *de*centralized network is a multiplication of the centralized network (see figure 1.2). In a decentralized network, instead of one hub there are many hubs, each with its own array of dependent nodes. While several hubs exist, each with its own domain, no single zenith point exercises control over all others.

There are many decentralized networks in the world today—in fact, decentralized networks *are the most common diagram of the modern era.*

One example is the airline system. In it, one must always travel through certain centralized hub cities—generally in the Midwest or central areas of the United States. Direct nonstop service is only possible if one happens to

3. Michel Foucault, *Discipline and Punish,* trans. Alan Sheridan (New York: Vintage, 1997), p. 197.

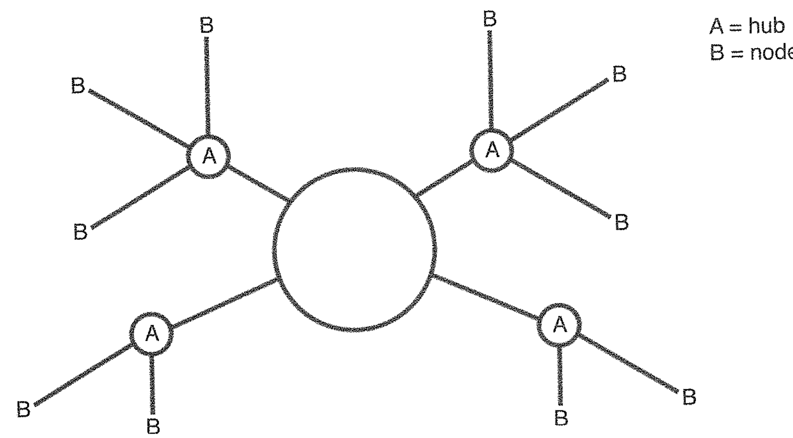


Figure 1.2
A decentralized network

be traveling from one hub to another (or if one pays a premium for special routes).

For the airline system, the decentralized network is the solution to multiplicity, albeit a compromise between the needs of the passenger and the needs of the airlines. There are far too many airports in the country to allow for nonstop service between each and every city; however, it would be inefficient to route every passenger through a single, Midwestern hub (e.g., consider a flight from North Carolina to Maine).

The third network diagram, the one that interests me most here, is called the distributed network.[4] The emergence of distributed networks is part of a larger shift in social life. The shift includes a movement away from central

4. In *Networks and Netwars*, Arquilla and Ronfeldt call this third network topology an "all-channel" network "where everybody is connected to everybody else" (p. 8). However their all-channel network is not identical to a distributed network, as their senatorial example betrays: "an all-channel council or directorate" (p. 8). Truly distributed networks cannot, in fact, support all-channel communication (a combinatorial utopia), but instead propagate through outages and uptimes alike, through miles of dark fiber (Lovink) and data oases, through hyperskilled capital and unskilled laity. Thus distribution is similar to but not synonymous with all-channel, the latter being a mathematical fantasy of the former.



bureaucracies and vertical hierarchies toward a broad network of autonomous social actors.

As Branden Hookway writes: "The shift is occurring across the spectrum of information technologies as we move from models of the global application of intelligence, with their universality and frictionless dispersal, to one of local applications, where intelligence is site-specific and fluid."[5] Computer scientists reference this historical shift when they describe the change from linear programming to *object-oriented* programming, the latter a less centralized and more modular way of writing code. This shift toward distribution has also been documented in such diverse texts as those of sociologist Manuel Castells, American Deleuzian Hakim Bey, and the Italian "autonomist" political movement of the 1970s. Even harsh critics of this shift, such as Nick Dyer-Witheford, surely admit that the shift is taking place. It is part of a larger process of postmodernization that is happening the world over.

hmmm. OOP: less centralized more modular

What is the nature of these distributed networks? First, distributed networks have no central hubs and no radial nodes. Instead each entity in the distributed network is an autonomous agent.

A perfect example of a distributed network is the rhizome described in Deleuze and Guattari's *A Thousand Plateaus*. Reacting specifically to what they see as the totalitarianism inherent in centralized and even decentralized networks, Deleuze and Guattari instead describe the rhizome, a horizontal meshwork derived from botany. The rhizome links many autonomous nodes together in a manner that is neither linear nor hierarchical. Rhizomes are heterogeneous and connective, that is to say, "any point of a rhizome can be connected to anything other."[6] They are also multiple and asymmetrical: "[a] rhizome may be broken, shattered at a given spot, but it will start up again on one of its old lines, or on new lines."[7] Further, the rhizome has complete disregard for depth models, or procedures of derivation. As Deleuze and Guattari write, a rhizome "is a stranger to any idea of genetic axis

5. Branden Hookway, *Pandemonium: The Rise of Predatory Locales in the Postwar World* (New York: Princeton Architectural Press, 1999), pp. 23–24.

6. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus*, trans. Brain Massumi (Minneapolis: University of Minnesota Press, 1987), p. 7.

7. Deleuze and Guattari, *A Thousand Plateaus*, p. 9.

or deep structure."[8] Trees and roots, and indeed "[a]ll of arborescent culture"[9] is rejected by the rhizome. Summarizing the unique characteristics of the rhizome—and with it the distributed network—Deleuze and Guattari write:

- [U]nlike trees or their roots, the rhizome connects any point to any other point . . .
- The rhizome is reducible neither to the One nor the multiple. . . . It is composed not of units but of dimensions, or rather directions in motion.
- It has neither beginning nor end, but always a middle (*milieu*) from which it grows and which it overspills.
- Unlike a structure, which is defined by a set of points and positions, with binary relations between the points and biunivocal relationships between the positions, the rhizome is made only of lines . . .
- Unlike the tree, the rhizome is not the object of reproduction . . .
- The rhizome is an antigenealogy. It is short-term memory, or antimemory.
- The rhizome operates by variation, expansion, conquest, capture, offshoots.
- The rhizome is an acentered, nonhierarchical, nonsignifying system without a General and without an organizing memory or central automation.[10]

If diagrammed, a distributed network might look like figure 1.3. In a distributed network, each node *may* connect to any other node (although there is no requirement that it does). During a node-to-node connection, no intermediary hubs are required—none, not even a centralized switch as is the case in the telephone network. Point "X" may contact "Y" directly via one of several path combinations.

A distributed network is always caught, to use an expression from Deleuze and Guattari, au milieu, meaning that it is never complete, or integral to itself. The lines of a distributed network continue off the diagram. Any subsegment of a distributed network is as large and as small as its parent network. Distribution propagates through rhythm, not rebirth.

8. Deleuze and Guattari, *A Thousand Plateaus,* p. 12.
9. Deleuze and Guattari, *A Thousand Plateaus,* p. 15.
10. Deleuze and Guattari, *A Thousand Plateaus,* p. 21, bulleted format mine.



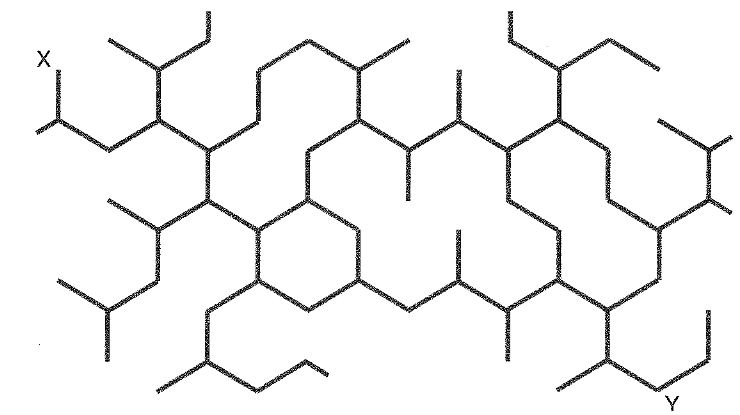


Figure 1.3
A distributed network

One actually existing distributed network is the Dwight D. Eisenhower System of Interstate & Defense Highways, better known as the interstate highway system. The highway system was first approved by Congress immediately following World War II, but was not officially begun until June 29, 1956, when President Eisenhower signed it into law. (This is exactly the same period during which Internet pioneer Paul Baran began experimenting with distributed, packet-switching computer technologies at the Rand Corporation.[11]) The highway system is a distributed network because it lacks any centralized hubs and offers direct linkages from city to city through a variety of highway combinations.

For example, someone traveling from Los Angeles to Denver may begin by traveling on Interstate 5 north toward San Francisco turning northwest on Interstate 80, or head out on Interstate 15 toward Las Vegas, or even Interstate 40 toward Albuquerque. The routes are varied, not predetermined. If one route is blocked, another will do just as well. These are the advantages of a distributed network.

11. As Hafner and Lyon write: "Baran was working on the problem of how to build communication structures whose surviving components could continue to function as a cohesive entity after other pieces were destroyed." See Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late,* p. 56.

The net was created to facilitate mobility & communication in case of war, and as a response to potential nuclear threats. (Interstate highway system as well).

Of course the Internet is another popular and actually existing distributed network. Both the Internet and the U.S. interstate highway system were developed in roughly the same time period (from the late 1950s to the late 1970s), for roughly the same reason (to facilitate mobility and communication in case of war). Later, they both matured into highly useful tools for civilians.

What was once protocol's primary liability in its former military context—the autonomous agent who does not listen to the chain of command—is now its primary constituent in the civil context. The diagram for protocol has shifted from the centralized to the decentralized network, and now finally to the distributed network. Distributed networks have no chain of command, only autonomous agents who operated according to certain pre-agreed "scientific" rules of the system.

For the Internet, these scientific rules are written down. Called protocols, they are available in documents known as RFCs, or "Requests for Comments." Each RFC acts as a blueprint for a specific protocol. It instructs potential software designers and other computer scientists how to correctly implement each protocol in the real world. Far more than mere technical documentation, however, the RFCs are a discursive treasure trove for the critical theorist.

The RFC on "Requirements for Internet Hosts," an introductory document, defines the Internet as a series of interconnected networks, that is, a *network of networks,* that are interconnected via numerous interfacing computers called gateways: "An Internet communication system consists of interconnected packet networks supporting communication among host computers using the Internet protocols . . . The networks are interconnected using packet-switching computers called 'gateways.'"[12] Populating these many different networks are hosts, single computers that are able to send and receive information over the network. According to this RFC, "A host computer, or simply 'host,' is the ultimate consumer of communication services. A host generally executes application programs on behalf of user(s), employing network and/or Internet communication services in support of this function. . . . Internet hosts span a wide range of size, speed, and function.

12. Robert Braden, "Requirements for Internet Hosts," RFC 1122, October 1989, p. 6.



All about the content

makes sure data arrives correctly. the content & raw act

Just the movement of data from one place to another

Hardware (fiber-optic cable, telephone wire)

conversation content

content is unimportant.

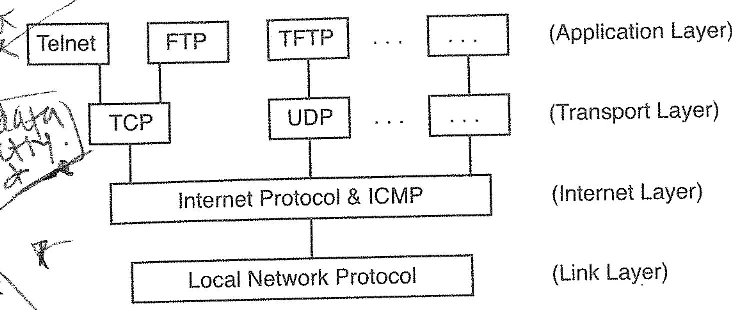


Figure 1.4
Protocol layers

They range in size from small microprocessors through workstations to mainframes and supercomputers."[13] Or, as the RFC on Transmission Control Protocol simply defines it, hosts are "computers attached to a network."[14] If the host is a receiver of information, it is called a client. If it is a sender of information, it is called a server.

In order for hosts to communicate via the Internet, they must implement an entire suite of different protocols. Protocols are the common languages that all computers on the network speak. These component protocols act like layers. Each layer has a different function (see figure 1.4). Considered as a whole, the layers allow communication to happen.

The RFC on "Requirements for Internet Hosts" defines four basic layers for the Internet suite of protocols: (1) the application layer (e.g., telnet, the Web), (2) the transport layer (e.g., TCP), (3) the Internet layer (e.g., IP), and (4) the link (or media-access) layer (e.g., Ethernet).

These layers are nested, meaning that the application layer is encapsulated within the transport layer, which is encapsulated with the Internet layer, and so on.

This diagram, minus its "layer" captions, appears in RFC 791. The four layers are part of a larger, seven-layer model called the OSI (Open Systems Interconnection) Reference Model developed by the International Organization for Standardization (ISO). Tim Berners-Lee, inventor of the Web, uses a

13. Braden, "Requirements for Internet Hosts," pp. 6–7.
14. Jonathan Postel, "Transmission Control Protocol," RFC 793, September 1981, p. 7.