3 From Network to Patchwork: Three Pioneering Network Projects That Didn't, 1959 to 1962

In the late 1950s and early 1960s, economic cybernetics—with its nonlinear mathematical mindset—appeared to be a near-perfect approach for modeling and reforming the economy's heterarchical coordination problems. (Cyberneticists were at home in the underlying observer-effect problems: the act of looking at a system changes the system.) Between 1959 and 1982, Soviet cyberneticists advanced a half dozen ambitious and creative plans to network their nation, including four overlapping attempts to digitize the command economy. Most of those proposals arose between 1959 and 1962 before they languished or merged with associated projects with more momentum, like the OGAS Project described in chapters 4 and 5.

This chapter reviews the three earliest Soviet network ambitions—Anatoly Kitov's EASU (Economic Automatic Management System), Aleksandr Kharkevich's ESS (Unified Communication System), and N. I. Kovalev's rational system of economic control between 1959 and 1962—in the context of the larger institutional struggles to secure support for their network projects. Some attention also is paid to the network projects that developed as civilian computer networks elsewhere and to the ways that the Soviet experience varies from the American ARPANET and Chilean Cybersyn projects. Through a discussion of leading Soviet network proposals to reform the command economy in the last few years of Khrushchev's reign (1959–1962), this chapter examines, details, and complicates the hypothesis that the administrative dynamics of a strong civilian-military separation help explain the stillbirth of their historic efforts.

Anatoly Kitov and EASU: The First Soviet Cyberneticist and His Civilian-Use Military Network

The first person to propose a large-scale computer network for civilian use anywhere, as far as I can tell, appears to have been the first Soviet cyberneticist, Anatoly Ivanovich Kitov (1920–2005). The son of a White army (Menshevik) officer who escaped persecution after the 1917 Russian revolution by moving from Moscow to central Asia and then to the city of Kyibishev (now Samara, Russia) on the Volga River, Anatoly Kitov grew up between two world wars. A star student in mathematics who rose rapidly through the military academy, Kitov served as a young officer on the front in World War II (where he, like other human "computers," computed ballistic tables), before launching a distinguished military career that suddenly shifted to civilian research for reasons described below (figure 3.1).

In 1953, Aksel' Berg, then deputy minister of defense in charge of radar and future dean of Soviet cybernetics, asked Kitov to prepare a report on the state of computing in the West.[1] Kitov's optimistic report resulted in the creation of three large computational facilities—the Computation Center 1 (which Kitov directed until 1959), the Navy Computation Center, and the Air Force Computation Center.[2] Kitov's optimistic review of computing in the West stemmed from his 1952 discovery of a copy of Norbert Wiener's *Cybernetics* that had been removed from general circulation (due to the ongoing anti-American campaign against cybernetics) and stored in a top-secret military research library. As noted above, in 1955, Kitov coauthored (with Lyapunov and Sobolev, two highly regarded Soviet mathematicians) the first Soviet article to attempt to rehabilitate cybernetics from

Figure 3.1
Anatoly Kitov. Courtesy of Vladimir Kitov.

the anti-American ideological critique that had been waged since its first mention in the Soviet press in 1948.

Kitov was not alone in seeing the potential for using computers in military work. Military and computing innovations were inseparable in the early history of computing. Although those early, specialized computer innovations for the military often had no measurable defense outcomes, their technological innovations seeped into nonmilitary industries. (Examples of military products that are now available commercially include jet planes, semiconductors, telecommunication and computer equipment, microelectronics, sensors, GPS, drones, and even Velcro, and only a few consumer electronics, such as game consoles and consumer electronics, have run the other way.[3]) In the United States during World War II, early military computer projects included the Whirlwind I (a vacuum tube computer), the Whirlwind II, and early attempts at computerized command and control, which in the 1950s led to SAGE (Semi-Automatic Ground Environment), which was a radio and radar network that stretched over most of Canada and was intended to intercept invading bombers from the Soviet Union. For its military purposes, SAGE was obsolete before it was operational, but its preparation nonetheless sparked a wave of influential inventions and major technical advances in computer systems and networks, including magnetic core memory, video displays, graphic display techniques, analog-to-digital and digital-to-analog conversion, multiprocessing, and automatic data exchange among computers.[4]

Alarmed by the news of SAGE in the mid-1950s, the Soviet military responded with at least three major long-distance computer networks—a missile defense system (System A in the late 1950s), an air defense system (the TETIVA in the early 1960s), and a space surveillance system (beginning in 1962). In the late 1950s, for example, a prototype missile defense system that was code-named System A (about which little else is known today) was built around a computer network that connected two Soviet mainframes, the M-40 and M-50, and a series of specialized computers at remote radar installations. Soon after the successful testing of System A in March 1961, Khrushchev boasted that Soviet antiballistic missiles could, in his famous phrase, "hit a fly in outer space."[5] More significant than the system's accuracy, however, was the fact that System A and its sibling military networks compelled a larger geostrategic shift: namely, antiballistic missiles that pointed skyward around the world greatly diminished the strategic value of a first-strike attack. Other networks, such as the space surveillance system started in 1962, connected a pair of distant nodes (one near Irkutsk on Lake Baikal in eastern Siberia and the other in Sary-Shagan in south central Kazakhstan) to a master computer center just outside of Moscow some seven thousand kilometers away. Other radar networks—named Hen House, Dog House, and Cat House—bathed vast swaths of territory in antiballistic alerts. The Dead Hand—the semiautomatic perimeter defense system noted in the introduction—is the present-day heir to these early Soviet military computer networks.[6]

Struck by the latent computational surplus that was available in military networks, Kitov turned his attention to how networked computing might be able to benefit the civilians who were supposed to be protected by the military.[7] In 1956, in the first Soviet book on computers, *Digital Computing Machines*, Kitov built on the insights of Leonid Kantorovich's linear modeling to promote a pioneering argument about the potential of the computer—although still without the network—as an essential tool for modeling, programming, and regulating the Soviet economy.[8] The idea of using high-speed digital computers to crunch economic statistics was nothing new. In fact, Kitov's proposal came as a mere technological update to a long-standing tradition of state-based mechanical computation. After the 1917 revolution, for example, the Bolsheviks quickly nationalized the Odhner calculator factory in St. Petersburg. By 1929, the year that farms were mass collectivized and planned, the Soviet Union employed statistical tabulation equipment—including a clone of the successful pinwheel Odhner arithmometer and IBM punch card machines—on the scale of the United States or Germany.[9] The etymology of the word *statistics* (German for "the science of the state," which replaced "political arithmetic" in English in the late eighteenth century) frames this trend as nothing peculiarly Soviet: modern states, from the census to taxation and conscription, have long made statistics their business.[10]

The initial idea of using unnetworked computers to process economic information—really no more than a modest technological upgrade that was in line with well-established state interests—had been gathering support since at least 1954, when Mikhail Kartsev, an engineer who participated in the construction of the M-1 computer, declared that cybernetic understanding of computers had to exceed narrow military tasks: "we are interested not so much in the military applications of mathematical machines or, more generally, new technical devices, but in their wider applications." His colleague Nikolai Matiukhin, citing the use of computers in U.S. business, stressed that "in a socialist country, … the mechanization of planning with the assistance of computers can and should be pursued to the largest extent possible."[11] The early Soviet information technologist Isaak Bruk, who developed the M-2 computer, picked up on the thread, publishing the first call to harness computational power into raising the quality of economic planning in a 1957 *Kommunist* article, "Electronic Calculating Machines: In the Service of the National Economy."[12] (Both Kartsev and Matiukhin continued serving in military careers.)

Not long after, from 1958 to 1959, Kitov and Bruk's proposal began to bear fruit as Gosplan constructed specialized computational centers (*vyichislite'nyi tsentri*) for economic accounting, which were to be under the control of the Economic Council within the Council of Ministers. Vasily Nemchinov, a leading Soviet mathematical economist, also championed the proposal for computer centers around the nation to improve planning. In January 1959, Kitov sent his first proposal directly to the top of Soviet power and called on General (then First) Secretary Nikita Khrushchev to recognize the need to use computers to process economic planning and to speed economic reforms, and with the letter he included a copy of his published book on digital computers.[13] None of these proposals mentioned a computer *network*—or its near synonyms (such as *base*, *system*, or *complex*)—that would be able to command the economy.

Kitov's first letter to the Central Committee in 1959 proved to be a success. Although Khrushchev probably never saw the letter, his message ended up in the hands of Leonid Brezhnev, who replaced Khrushchev as general secretary in 1964. A trained technologist who had studied metallurgical engineering in eastern Ukraine, Brezhnev approved the proposal and ordered a government resolution to review and execute Kitov's recommendations. A commission led by Aksel' Ivar Berg was created to enact the Communist Party resolution called "The Speeding and Widening of the Production of Calculation Machines and Their Application to the National Economy." Berg cut a cosmopolitan figure (Berg's mother was Italian, and he was a Swedish Finn) in the administrative support of Soviet cybernetics, and he rose through the military ranks to serve on the State Committee of Defense after World War II with special emphasis on military and naval matters. Rescued from a sunken submarine near Helsinki in 1918, he directed radio technology research for the Red Navy, was imprisoned during the Great Terror for spying, returned to research during World War II, and was vice minister of defense in charge of national radar and radio technology from 1953 and 1957. In this position, Berg provided critical administrative support to the efforts of many early cyberneticists, including Kitov, Lyapunov, and others. Appointed to serve as the chair of the Council for Cybernetics in 1959, Berg, perhaps not unlike Vannevar Bush, exerted an extensive range of administrative influence over the state of Soviet cybernetic science for the next two decades.[14] With Berg's support, Kitov's first letter to Khrushchev set into motion a sea change that swept up strong state support for cybernetics.

A signal political victory, Kitov's initial vision imagined computers as devices for local computation but not yet for national communication. Like his predecessors, he proposed that "electronic calculating machines" must be used in "automating administrative and economic governance" in planning for the then seven-year plan for the command economy.[15] He also called for a "reduction of the administrative-management personnel" for engaging in "outdated means and methods of leadership." This could take place at local levels by means of local control systems, called automated systems of management (ASUs) (*avtomatizirovannie sistemi upravleniya*). ASUs were automated control systems at the level of the factory—a kind of local area network that allowed mainframe computers to control and communicate with factory machinery through a series of automated feedback loops and programmable control processes. In the 1960s, ASUs were developed and implemented in individual Soviet factories incrementally, and their use increased slowly in the 1970s and 1980s.[16] By the early 1960s, the notion of ASUs—or computer systems for monitoring local industrial processes and automatically optimizing those processes for efficient outcomes—gained popular traction among factory and enterprise managers around the country. On the cusp of the 1960s, enterprising military researchers like Kitov saw the advanced computer technology behind ASUs as promising new efficiencies, savings, and economies of scales at the factory and enterprise levels.

The next step was to nationalize the ASU and make it go "all-state" (adding the prefix *OG* for *obshche-gosudarstvennaya* to form the OGASU). This step appears obvious today, but the consequences of that step must have been hard to foresee then. In fact, encouraged by the success of his first letter, Kitov shifted his attention from local computation to national communication. In the fall of 1959, he drafted and sent to the Party leadership a second, more ambitious letter that eventually became known as "the Red Book" letter due to the color of its cover. The Red Book letter embraced a far more radical idea—the first wide-area dual-purpose computer network that could support both military and civilian uses. In his proposal, Kitov conceived of a "unified automated computer network" for administrative control of both military and economic affairs that would be built on the extant territorywide lattice of Ministry of Defense computer centers. Although electrical telegraphs had been instantaneously connecting paying publics across long distances since the mid-nineteenth century, evidence indicates that Kitov's 1959 proposal for a dual-use network was the first anywhere to suggest allowing civilians to use military computer networks to work on national problems.

Kitov named this first national network the Economic Automatic Management Systems (EASU, for *Ekonomicheskaya avtomatizirovannaya systema upravleniya*), a short step from the local area networks of the ASU. The EASU was meant to be more than a colossally oversized ASU, or factory-based automated management system, however: it was to be a dual-use network that would overlay and manage existing information flows within the Soviet economy with "large complexes" of computer centers. The long-distance economic ASU began to articulate in technological terms the underlying Marxist conception of the national economy as a single complex industrial body. The informing values for the earliest Soviet networked vision were in context both technologically ambitious and political self-evident.

The EASU proposed for the first time a long-distance communication infrastructure to transform the command economy into what it had effectively thought itself to be—a single nationwide corporation devoted to producing one product, which was social life outside the reach of capitalism. The basic communications infrastructure for such an upgrade was fairly straightforward. What Kitov called a "complex of computers," or a computer network, would use Ministry of Defense computers to optimize national economic planning and streamline the bulky and inefficient administration for planning the Soviet national economy. Each powerful computer center in the network would build on military computing locations that already were underground, well protected from the threat of enemy bombing and natural interference above ground. In addition, each underground military computer center would connect to accessible computer terminals that were located in cities above ground where "civilian organizations" could receive, send, and employ "unlimited quantities of reliable calculating processing power."[17] The military's automated missile computer network systems would serve, in Kitov's vision, as the technical platform for computationally monitoring and managing the national economy.

Kitov went considerably further than most military men of the time in proposing dramatic financial savings and benefits for the state. Electronic economic reform would also help quicken, Kitov added, the currently sluggish and inadequate adoption of computer technology by the Ministry of Defense. As part of that criticism, he called for the creation of a new governmental body that would be charged with overseeing the reform of all institutions, including both military and civilian, that were associated with planning the national economy.

With a proposal that criticized the military and proposed a civilian-military project, Kitov sent his letter to Khrushchev sometime in the fall of 1959 with the "hope that it would be accepted," he later remarked, "just as easily as the previous one."[18] Unfortunately, the precise fate of Kitov's second letter—the Red Book letter—remains unclear (in 1985, Kitov recalled that his letters to Party leadership were "jammed," or *strevali*).[19] We do know that the second letter never arrived at the desk of Khrushchev, Brezhnev, or any member of the first secretary's inner circle like the first letter had. Instead, the letter—with its criticism of the military and proposal to share military technology with civilians—fell into the hands of his military supervisors, who were infuriated. Without Berg's support and under his military supervisors' initiative, a special military commission was convened to review Kitov's report.

The highly respected high-ranking war hero Field Marshall K. K. Rokossovsky chaired the commission as then chief inspector of the Ministry of Defense. Rokossovsky—who survived the great purge, show trials, and torture under Stalin—might have been sympathetic to Kitov's case had he actually attended the commission. As it happened, however, Rokossovsky barely participated in the commission, leaving Kitov's fate in the hands of his supervisors, who rejected the proposal and followed standard Soviet procedure in burning the unapproved (and irreproducible) proposal in what colleagues later referred to as Kitov's show trial.[20] "Hence the paradox in technics," as Lewis Mumford put it: "war stimulates invention, but the army resists it!"[21]

Incensed by Kitov's critique, the unchecked commission exacted further retribution by revoking his Communist Party membership for the following year and dismissing him from military leadership, his position as the director of Computational Center-1 of the Ministry of Defense, and effectively his once meteoric military career. To justify this punishment, the special commission deemed Kitov's proposal "inefficient" for having suggested that civilians should use of military technologies, disregarding any discussion of his promised cost savings and efficiencies. The commission also issued a formal complaint against Kitov for not having filed his network proposal according to proper protocol. He was to be punished formally for having attempted to send his communiqué to Khrushchev directly, bypassing the intervening administrative tiers between him and the Party leaders.

Given the success of his first improperly filed letter to Khrushchev earlier that year, a breach in filing protocol struck his colleagues as a disingenuous and insufficient cover for severely punishing an army researcher who was celebrated for having done something similar a year earlier. Eyewitnesses confirm that the commission's unwritten response had little to do with filing protocol, efficiency, or any other stated reason. Instead, they underscored the military's possessiveness and unwillingness to share information technology with the civilian sector. As Kitov later exclaimed in an interview, the commission's unwritten response was essentially that "the army will never occupy itself with fulfilling any tasks concerned with the national economy!"[22]

Most notable about Kitov's show trial is not the possessive self-interest that motivated a large institution to punish its own—an instinct that animates most centralized command-and-control administrations, including the military portion of the Soviet knowledge base—but rather the counter-innovational institutional conditions that sanctioned the military command to separate military and civilian resources, both economic and technological. The military top brass decided to hoard its computing resources, neither acknowledging the Politburo's support of Kitov's proposals nor concerning itself with any commercial or civilian application. Kitov's military supervisors were free to act as they pleased, denouncing any time sharing of their computer networks with others, even if doing so at night would have had no obvious cost to the military and would work against the interests of the top state leaders of the nation that the military was sworn to protect.[23]

Kitov's show trial also showcases the informal and contingent dynamics that beset anyone trying to bridge the entrenched military-civilian divide. Although Kitov's first letter circumvented formal protocol without a hitch, the second letter, which included military criticism, was intercepted. The military man who was most likely to be sympathetic to Kitov's case did not attend the commission that he formally chaired. Informal degrees of freedom, in turn, allowed Kitov's military supervisors, according to eyewitness reports, to pronounce his proposed military-civilian nationwide network an existential threat—not as much to the nation as to their personal and unprecedented control over the resources of the nation.[24] An automated computer network threatened to automate and jeopardize the Ministry of Defense's positions of power over strategic bottlenecks of resources in information technology, granting civilian economic planners access to the ministry's technological monopoly.

Kitov's first public computer network proposal ended his military career and launched his career as a civilian network entrepreneur. In his many publications promoting automated computer networks in the national economy between 1959 and 1967, he continued to frame the economic race in terms of military competition between the superpowers.[25] In a 1959 article with Berg and Lyapunov, for example, Kitov announced to his readers that the automation of firm-level economic management resulted in major savings and "reductions in the administrative apparatus (in some cases 80–90%)."[26] In 1961, his advice to reform economics with computer methods—without the military network—successfully secured the support of the top Party leadership in the form of a Party report that helped pave the way for Khrushchev at a Party Central Committee Plenum in November 1962. At that plenum, at the height of the cultural thaw and the eve of the economic debates described previously, Khrushchev called for the adoption of Western "rational" managerial techniques, proclaiming that "in our time, the time of the atom, electronics, cybernetics, automation, and assembly lines, what is needed is clarity, ideal coordination and organization of all links in the social system both in material production and in spiritual life."[27] In many ways, influencing the leaders of the Soviet state with cybernetic ambitions about networking the civilian economy proved easier than bridging the military-civilian divide.

The Soviet military behaved as a well-oiled hierarchy when it limited scientific or technological transfer outside of itself, although like the economy and Party apparatuses, its internal affairs could be unpredictable and tenuous. Kitov's case raises the point that so long as the military did not have to associate its resources with nonmilitary projects, it was content to manage its own internal affairs however it wished. So long as the Party agreed (and often when it did not), it behaved as a private household unto itself. This unpredictability could swing for or against military personnel. In a well-ordered, top-down hierarchical military, research scientists are not usually expected to be able to send letters directly to the heads of state or to influence state policy with those letters. At the same time, a well-ordered military probably would not permit middle-level administrators to dismiss a star scientist from the army for proposing cost-saving procedures that already were supported by the heads of the state, and if such a trial did take place, the appointed dignitaries surely would attend and dismiss the case. Yet none of this happened to Kitov, among untold others—and no one found these events unusual.[28]

The Historical Concurrence of Cold War Networks

Because international communication networks precede national computer networks, multiple network projects often emerge in very different places at about the same time, and priorities are often the last thing to be prioritized. By my accounting, Kitov in the fall of 1959 was the first to propose a national computer network for civilian communication anywhere, although this or any other "first" claim ignores the complex interdependencies of institutions and individuals that create any major technological project. The rush to make "first" claims usually is seen in histories of technological invention (especially histories written by retired professional technologists) to enhance biographical hagiography and ignore claims made elsewhere. It also can be difficult at the edge of any innovation to distinguish between a slight improvement to an old technology and an altogether new technological invention. Kitov's EASU, like most of the proposals examined here, assembled a network out of preexisting and new telegraphy, telephone, radio, and radar networks. Rather than thinking of them as computer networks, EASU was framed more as telephone networks with computers. Simultaneously, the Soviet military, including computer network designer Nikolai Matiukhin, knew of and sought to imitate the automated air defense radar network that went operational in the United States in 1958, although little about the classified SAGE project or its classified Soviet equivalent filtered into civilian science.[29]

Thoughts about ambitious civilian networks were percolating elsewhere as well. Just months after Kitov's second letter, the American psychologist J.C.R. Licklider's 1960 essay "Man-Computer Symbiosis" featured a vision of the potential social and civilian benefits of computers, although (with one footnoted exception) his essay restricts itself to local human-computer intersections. In that footnote, he "envision[s], for a time 10 or 15 years hence, a 'thinking center' that will incorporate the functions of present-day libraries." From here, "the picture readily enlarges itself into a network of such centers, connected to one another by wide-band communication lines and to individual users by leased-wire services. In such a system," Licklider concludes, "the speed of the computers would be balanced, and the cost of the gigantic memories and the sophisticated programs would be divided by the number of users."[30] In 1963, Licklider scaled up his vision of that network as a library with an internal memo that was titled (half in jest) "Memorandum for Members and Affiliates of the Intergalactic Computer Network" and that sketched out the system that became the ARPANET—the technical predecessor to the Internet.

Despite their historical concurrence, all available evidence signposts that the early Soviet economic networks and the ARPANET developed independently of one another. When the ARPANET went online in 1969, it took the Soviet state by surprise. I have encountered no evidence to imply that Kitov or others knew about Western computer network developments other than the SAGE project. Nor have I found evidence that the American secret intelligence community knew about Soviet cybernetic developments before 1964, when Soviet specialists at the CIA began wringing their hands about Soviet cyberneticists working on a nonmilitary "unified information net."[31] Although subsequent Soviets would first pioneer socially ambitious nationwide network projects, the front of Soviet network projects, like the science of cybernetics that underwrote it, proved anything but unified.

Other forms of international influence did lead to networks elsewhere. In October 1957, for example, Soviet authorities set into motion events that led to the ARPANET. Soviet rocket scientists used a missile to launch the first manmade object into terrestrial orbit—*Sputnik I*, the first artificial satellite. At the height of the cold war space race, *Sputnik* came after a number of worrying developments. In November 1955, the Soviets air-dropped their first thermonuclear nuclear bomb, during a time of tension when many American military strategists believed, probably incorrectly, that the Soviet fleet of long-range bombers could reach American targets. The "bomber gap" crisis in the mid-1950s, which was unfounded but drove defense spending, launched that gap into orbital space. With *Sputnik* in orbit, the natural next step was as obvious as it was terrifying: if a warhead were placed atop such satellites, the world could be destroyed in a matter of minutes.

In February 1958, five months after the *Sputnik* crisis, the United States Defense Department created the Advanced Research Projects Agency (ARPA). This new government agency was charged with investing in and advancing the frontiers of technology research beyond the immediate needs of the military, especially in the spheres of space, ballistic missile defense, and nuclear test detection. ARPA did not stay focused on militarizing space for long, however. Two years after its creation, ARPA ceded its space research jurisdiction to the distinctly civilian mission of the National Aeronautics and Space Agency (NASA), which also was founded in 1958. ARPA research then turned toward supporting basic, high-risk, and long-term military research in information processing and computer systems for tracking nuclear threats in the age of *Sputnik*.[32]

The focus on basic computer research questions made ARPA an optimal site—under the auspices of the U.S. Department of Defense, a paragon example of a command-and-control hierarchy—for open-ended basic research. Early computer innovations advanced by ARPA researchers include distributed networking, time sharing, and packet-switching technologies (noted below). In 1965, shortly after President Lyndon B. Johnson called for "creative centers of excellence" to advance basic research among universities, the Department of Defense recommended using the ARPANET to connect preexisting, government-supported computer research sites across the American academy—first at the University of California at Los Angeles, Stanford University, UC Santa Barbara, and the University of Utah and then eastward to the Massachusetts Institute of Technology, Carnegie Mellon University, Harvard University, and other universities.[33] The Soviet military-civilian divide barred similar wide-scale collaboration between defense projects and university contractors.

The ARPANET went online on October 29, 1969, as the first large-scale, dual military-civilian use, packet-switching computer network in the world, the "Mother of all nets" as it has since been known. In its first stage, the ARPANET consisted of leased telephone lines and modems connecting computer terminals at UCLA, Stanford, UC Santa Barbara, and the University of Utah. The first message sent was the prophetic utterance *L* and *O*—"lo," not as in "lo and behold" but as in the first two letters of the word *login* that could be sent before the network crashed.[34] ARPA directors in the 1960s negotiated careful balances between Congress (to whom the directors promised research that could be applied to national security issues) and academic research contractors (to whom the directors promised the freedom of basic research that would be independent of any defense rationale).[35]

The heyday of military research in the 1960s came to an end in the political wake of the Vietnam War when in 1969 the first Mansfield amendment curtailed military spending on science across the board and in 1973 the second Mansfield amendment dramatically limited ARPA funding to appropriations for research directly related to military applications. ARPA, stripped of the capacity to do basic research, saw many researchers migrate to a fledgling computer industry, most famously Xerox PARC. Such a brain drain or labor migration from the military to the civilian sector would have had to be directed by military and state oversight in the Soviet Union.

So although in both superpowers the early computing industries in the 1950s through early 1970s depended on military state projects (with private contractors used as spinoffs as well as employed by the U.S. Air Force as its research consultancy), the biggest advantage that the United States wielded over the USSR appears to have less to do with the market independence of the private commerce than the porousness of research, resources, and knowledge flows between military and civilian projects. The modest and mixed military-civilian origins of the ARPANET are worth bearing in mind as well: the ARPANET was designed and launched explicitly for civilian scientists to exchange data at a distance. Its affordances as a network for national communication became obvious after the fact with the invention of email in 1971. At the same time, these civilian, public networked computing utility services were initially funded because of the military justifications to design, fund, and build a nationwide communication network that could survive a nuclear attack by the Soviets. This military motivation led Paul Baran's innovations at RAND in distributed networking and packet-switched networking and distinguished the ARPANET from other networks of its time. The emerging thesis here appears to be that the virtue of the military-industrial-academic complex in the United States rested on not the state, the market, or civilian research but on the *complex* that connected these sectors.[36]

Meanwhile, Chile under Salvador Allende (1970–1973) and France in the 1980s developed large-scale national networks. Unlike the strict Soviet divide between military and civilian research and more like the far more synthesized "military-industrial-academic complex" in America (perhaps the most important element of that phrase for understanding midcentury big science are the hyphens), the cases of Chile and France show that the international history of civilian networks cannot be easily separated from that of military networks. The Soviet military tightly siloed its technical innovations, the East German Stasi shuttered its large-scale computer network capacities from serving and transferring to civilian applications, and the West German government also forbade the transfer of network capacities from military to civilian.[37]

No country escaped institutional frustrations in developing nationwide computer networks. At important times, the complex in cold war American science proved vexatious, if not impossible, to navigate. Take, for example, Paul Baran (1926–2011), a Polish-born engineer who was raised in Philadelphia and Boston. Baran is widely remembered today for innovating packet-switching and distributed-network designs, which now are central to modern-day networking, but his struggles are less well remembered. In 1960 at the RAND Corporation, a research think tank under contract with the U.S. Air Force, Baran articulated the "hot-potato heuristic" behind modern-day data traffic on the Internet: break down a message into packets (or envelopes) of information, release each packet to travel on its own traffic-reducing pathway to its final destination, and resequence and receive all packets in their original order. In the early 1960s, Baran also designed the celebrated idea of a distributed network in which every node in a network connects to its neighboring nodes and not to any decentralized or centralized node arrangement (figure 3.2).

Widely celebrated as a prototype to "end-to-end" intelligence and a liberal democratic mode of communication, Baran's network innovations were colored and shaped by the cold war military complex as well as cybernetic sources. In the embarrassing aftermath of *Sputnik*, the U.S. Defense

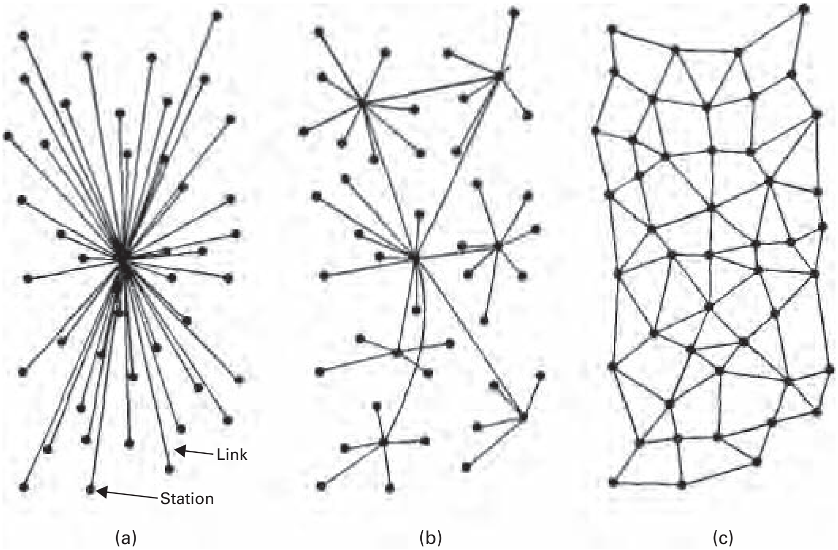

Figure 3.2
Three network types: (a) Centralized, (b) decentralized, and (c) distributed. *Source:* From Paul Baran, "Introduction to Distributed Communication Networks." *On Distributed Communications,* RAND Corporation Memorandum RM-3420-PR, August 1964, 2. Reproduced with permission of The Rand Corp.

Department ordered ARPA to design a "survivable" network that would last long enough in a nuclear strike to send a "go-code" to guarantee "second-strike capability." "There was a clear but not formally stated understanding," noted Baran, "that a survivable communications network is needed to stop, as well as to help avoid, a war."[38] A network that can survive an enemy attack could ensure the threat of the mutual nuclear annihilation—a threat so cataclysmic that it would rationally deter (Baran and his military superiors hoped) either the Soviets, the Americans, or any other nuclear power from striking first.[39]

Baran's inspiration for packet switching as a way to build a survivable network traces back to Warren McCulloch's cybernetic conception of the human brain as a complex and resilient logical processor. As Baran reported in an interview with Stewart Brand, "McCulloch in particular inspired me. He described how he could excise a part of the brain, and the function in that part would move over to another part."[40] The same interview lists McCulloch and Pitt's 1943 paper on neural networks as a sensible reference, although Baran also noted that he was reading more broadly in the "subject of neural nets," a literature that probably included McCulloch, Pitts, Jerome Lettvin, Humberto Maturana, and others. Much of this characterized “McCulloch’s version of the brain,” which, Baran continued, “had the characteristics I felt would be important in designing a really reliable communication system.”[41] Reliable national computer networking were inspired by models of complex (heterarchical) neural networks.

The result of Baran’s conversations was packet switching, a technology that broke messages into “packets,” which allowed digital “bursts” of data to be rerouted around damaged parts of a network—just as the brain can reroute neural impulses around damaged neural matter. Similarly, Baran’s observation was that, due to network effects, the brilliance of a distributed network, whether neural or national, is that it does not need each of the average eighty-six billion neurons in the human brain to connect to every other (and the number of possible connections between eighty-six billion neurons is so incomprehensibly large that the need for robust reconnection becomes obvious).[42] Rather, attaching to a couple of other nodes allows a distributed packet-switched network to reroute in real time around damaged territory, whether neural or national.

The governing logic behind Baran’s innovations is curiously the same as McCulloch’s heterarchy: in a heterarchy, the relations between nodes can be ordered and evaluated in more ways than one, and there is no overarching governing structure, no internal logic, and no accounting regime for determining how nodes interconnect. Both lack a fixed control center or mother node. Baran did not concern himself with theorizing about a distributed communication network as a neural network for the nation, as a cyberneticist might. McCulloch’s ideas about the brain as a self-governing network helped Baran to arrive at concrete pragmatic solutions to the overarching military orders of his employer. The Internet, in this sense at least, traces its intellectual sources back to cold war cybernetics.

Baran’s network innovations do not arrive without serious institutional and international complication. Although technically on target, Baran’s ideas were not influential until after a foreigner—an Englishman named Donald Davies, with the UK Post backing him—independently discovered and articulated packet switching. Only then did Baran’s superiors in the U.S. military-industrial complex start paying attention to his ideas. In fact, between 1960 and 1966, AT&T repeatedly declined or delayed his proposals to develop digital communication networks. As one AT&T official told him, the near nationwide monopoly on analog telephony networks was not about to go into competition with itself. When it appeared that the air force stood ready to implement Baran’s ideas without AT&T, Baran withdrew his proposal because he felt that the appointed government agency, the Defense Communication Agency, would "screw it up and then no one else would be allowed to try, given the failed attempt on the books." With no such "competent organization" in sight and after spending six years aggressively publishing his network research internationally to ensure maximum circulation about how survivable communication networks could help ensure mutual deterrence, Baran despaired at the local prospects and turned his attention elsewhere.[43] The popularity of the phrase *packet switching*, which was Davies's term, and the obscurity of Baran's initial coinage *block switching* are evidence that it took outside competition to spur local authorities to take packet switching seriously. The U.S. ARPANET, despite the efforts of its own network entrepreneurs, was inspired by foreign founders. To the degree that Stigler's law of eponymy holds—"no scientific discovery is named after its original discoverer" (a law that Stigler attributes with a grin to Robert Merton)—Baran's case rehearses not the exception but the rule that international communication networks precede national computer networks.

Aleksandr Kharkevich's Unified Communication System (ESS)

At the same time that Paul Baran was publishing his network research in the hopes of ensuring the Soviets would have access to survivable communication networks and that J.C.R. Licklider was thinking about computer networks as pragmatic tools for facilitating long-distance exchange of scientific data, Soviet cybernetic network entrepreneurs were imagining computer networks as ambitious infrastructural solutions to the nation's most pressing civilian problems. In the imaginative minds of the three Soviet cyberneticists chronicled below, digital computer networks were models both of and for the entire nation.[44] These and other early proposals for a "unified system of calculating centers for the development of economic information" found their earliest inspiration in the 1955 Academy of Sciences proposal by Vasily Nemchinov (two years before *Sputnik* and well before the invention of the ARPANET) that considered erecting large but unconnected state computer centers (in Moscow, Kiev, Novosibirsk, Riga, Kharkov, and other major cities) that could facilitate the local exchange of scientific reports and economic information among regional economists. One of those proposals—Kharkevich's unified all-state system for information transmission—has been relatively neglected in previous commentary and receives additional attention below.

In 1962, Aleksandr A. Kharkevich, then deputy chair of the Council on Cybernetics, proposed a communications network for the entire nation, although this proposal—for a network that was formally called the "unified all-government system for the transmission of information" (*edinaya obshchegosudarstvennaya sistema peredachi informatsii*)—did not seek to solve an explicit civilian-sector problem, unlike other contemporary Soviet network projects. In fact it sought to solve no particular problem at all: it was proposed out of sheer technical ambition to build a national communication network on preexisting telephony and telegraphic channels for all kinds of data exchange. The closest that Kharkevich comes to a social justification is noting, without comment, that it will "broaden the sphere of human activity."[45] The technical orientation of data exchange in Kharkevich's proposal resembles the purpose of the ARPANET as a network for exchanging data between scientists. With similar "intergalactic" ambitions, Kharkevich set out to optimize all technical communication problems at once by proposing to merge all Soviet data streams into a single nationwide digital communication network. His 1962 proposal came to light in an article titled "Information and Technology" that was published in the leading periodical *Communist*, in which Kharkevich apparently renamed this network with the more workable title of "unified communication system" (ESS, for *edinaya sistema svyazi*), a possible source of the uncited CIA speculations about a menacing Soviet "unified information net."[46] His vision describes a technical future that was obvious to information theorists, who were the technocratic twin of cyberneticists and could be traced back to Claude Shannon of Bell Labs and his seminal 1948 article "A Mathematical Theory of Communication." (Kharkevich was himself a leading information theorist and specialist in noise reduction in electronic communication signals.)[47]

In the 1962 *Communist* article, Kharkevich proposes that the ESS unified network of information transmission be built, like the other proposals here, on the preexisting telephone and electronic network infrastructure, which he found analogous to a nationwide railway network that was built to transmit, store, and process digital information messages. Given that most Soviet citizens had to use public phones in 1962, this was a fantastically far-fetched technical proposal on any terms. Perhaps for this reason, he devotes almost the entire twelve-page article to the technical capacities of such a network (for example, how messages would arrive at the right place without data loss), which were grandiose. Telegraph cables, telephone lines, radio waves, and all other technical communication channels were to be unified into a common digital and "enciphered" currency that would be related by binary electronic pulses over telephone wires. The irreducible denominator to his technocratic vision was the concept of information: "the far-reaching role of information has become clear not only in the relations between people, but also in the interactions between man and machine, as well as in the life of any organism." He continued, "with the enhancement of economic, technical, and cultural levels of society, the amount of information necessary to collect, transmit, and somehow provide for all functions of the community of people grows faster and faster. No organized form of activity is thinkable without information exchange. Without information, planning and governance are impossible."

Backlit by the stated universal need for information, Kharkevich justified the network proposal by citing the "prominent system 'SAGE'" computer system in the United States and Canada as a parallel to his vision of a narrowly applied, universal information system for antiaircraft defense. The top of his pyramid, ESS network design, was meant to "fulfill the function of the dispatcher of the network," or "the center will be constituted by a large group of specialized calculating-logic machines, appointed for the direct resolution of the many changing conditions of one single task: the supply of increasingly favorable conditions for the appointment of all currency flows of information."[48] The Soviet Union did need not to stop at antiaircraft defense, he said, concluding his "grandiose thought" of an all-reaching, full-service ESS network with the observation that "creating an all-state unified system of connection … would only be possible in a socialistic government under the conditions of a planned economy and centralized government."[49]

Kharkevich's article is remembered among some technologists today not for proposing the ESS but for formulating what became known as Kharkevich's law. This law holds that the quantity of information in a country grows proportionally to the square of the industrial potential of the country (N^2). The original formulation of his observation in the article is perhaps less elegant than information technologists might remember: "Given a large number of factories, the number of paired links between them is approximately equal to half of the square of the number of factories."[50] The law, in effect, prophesies a power law connection at the macro level between an industrial society and an information society. In 1965, the American computer businessman Gordon Moore expressed a distinct exponential law that has applied to the microscopic level of the compounding growth of silicon chip production—that the number of transistors on an integrated circuit doubles every two years (2^N).[51] Both men foresaw in 1962 the emerging information sector or what Austrian American economist Fritz Machlup called "the knowledge economy." For Kharkevich, the amount of information that a society processes can be expressed as a power law function of the industries it contains, and for Moore, the amount of information that a society processes can be expressed as an exponential function of the transistors on the circuits its industries can produce.[52] These sibling laws (Moore's 2^N and Kharkevich's N^2) diverge interestingly in complex systems (when N is larger than 4). They also backlight their micro and macro focuses—Moore on microscopic industrial production and Kharkevich on informational industrial society. The result is different framings of the national network as a sort of central processor. Like Baran, Kharkevich prioritizes building "survivable" military networks while also looking to benefit other civilian and social goals.

Unlike the cybernetic metaphor of the brain that Baran drew from Warren McCulloch, Kharkevich saw his national network as a nervous system that was overlaid onto the body of the nation and that would be governed by a central processor, or brain, located in Moscow. The resulting contrast of cybernetic metaphors for the information societies is again sharp: for Kharkevich, the networked nation was the body controlled by a central brain, and for Baran, the networked nation was the brain itself.

Like other network designers, Kharkevich also designed the ESS network after the formal administrative structure of the nation that he imagined it would network. "It is natural that the network should be supervised," he wrote, "by the Ministry of Communication [Svyaz'] in the Soviet Union," the ministry that managed many preexisting networks for information exchange, including telegraph, telephone, phototelegraph, messages (courier), and early digital technologies then available in small numbers. Kharkevich breezily dismissed the distributed network model that Paul Baran was developing at the time (although not by that name), observing that the structure of the network needs to be able to connect any two nodes, and he writes, "in order to do this, it goes without saying, one does not need to unite all nodes with separate lines."[53] Instead, Kharkevich considered a hierarchically decentralized design, or pyramid structure, "the rational structure of a network."[54] Like transport roads, his network would split out in a "radial system" in which a "given territorial group is united by links to a communication node." Just as every local, regional, and territorial group would have its own common node, Kharkevich was quick to stress the center that was implicit in this "radial" design. In 1962 in Moscow, a "centralized automated management" design would have appeared reasonable, if still monumental in aspiration, to him:

> The brisk carrying out of these functions is possible only … if the entire network will work under centralized automated management. The governing center of ESS should distribute information about the state of the network at every given moment.… The center should be capable of predicting such changes [in the network traffic]

slightly in advance and create the needed operating reserves. The center appoints the pathways for the passage of flows of information as they depend on the general state of the network; in the case of necessity [*nadobnost'*], the center will be able to focus all network resources on fulfilling special information transmission tasks. In short, the governing center of ESS fulfills the function of the dispatching manager of the network.[55]

Here, without the benefit of packet-switching protocols, Kharkevich anticipated the needs of a nationwide network to adapt automatically in real time to traffic jams as well as the capacity to complete "special information transmission tasks" (the sending of nuclear "go-codes" in the case of nuclear "necessity"). Automation appears to be the ultimate nuclear safeguard, for he continues that "it will not be possible to give these functions to people. The center will constitute a large group of specialized calculating-logical machines, appointed for the direct resolution of the changing conditions of a single task: providing increasingly favorable conditions for the appointment of current flows of information."[56]

The fate of the ESS owes less to the technicalities of its design than to the muses of institutional historical contingency. In 1961, the year before he proposed the ESS, Kharkevich was made director of the Institute for the Problems of the Transmission of Information (IPPI), the new Soviet Academy of Science's research center on information technology. The president of the Academy of Sciences, Mstislav Keldysh, a rocket scientist and mathematician who helped develop the Calculation Bureau during World War II, created Kharkevich's IPPI in the same year that he created Glushkov's Institute of Cybernetics in Kiev and Fedorenko's Central Economic-Mathematical Institute in Moscow. In 1963, Kharkevich's ESS vision took its first step forward when the Ministry of Communication created an interagency Coordinating Council, chaired by the then minister of communications, General-Colonel N. D. Psurtseva, to supervise the creation and standardization protocols for the ESS. However, before any the council could make concrete progress and three years after proposing the ESS, the project collapsed. On March 30, 1965, Kharkevich died of protracted health problems at the age of sixty-one. Why no one took up his reigns on the ESS proposal remains unclear, although the lack of evidence implies that the ESS's political prospects passed into history with Kharkevich.

N. I. Kovalev's Rational System for Economic Control

Consider still another short-lived and concurrent network proposal, whose fate archival materials and interviews have not yet clarified. In the

November 1962 Plenary Meeting of the Communist Central Committee, decisions were made to mechanize and automate both the industrial processes and the administrative control over those processes. In the 1963 issue of *Problems of Economic Transition*, N. I. Kovalev, then the director of the State Economic Council (*Goseconomsovet*), published a proposal that elaborated on those decisions and proposed creating and connecting the preexisting major computing centers for each of the regional economic councils (*sovnarkhozy*) that Khrushchev initiated in 1957. Like all the others, Kovalev's design also mapped a pyramid communication network onto the economy's three-tier hierarchy of ministry, regional council, and local enterprise. The network was meant to help the regional councils to receive otherwise unspecified "necessary information" on time. No longer would "the report materials arrive so late that they cannot be effectively used to plan and govern the national economy."[57] Citing Nemchinov and Glushkov (prominent specialists in the field who are featured in the next chapter), Kovalev estimated that the network would cost 94 million rubles, the first layer of thirty computing center would require three years to complete, and the economic savings would far outweighing the costs.[58] By referring to such a computer network as a "rational system," Kovalev did not emphasize the transformative effects of long-distance real-time computer networks but instead stated a need for vaguely specified "cybernetics, electronic computing and control devices" to serve as the "material and technical base" for a transition to a communist model for "planning and controlling the economy" over the next two decades.

Kovalev's proposal stands as a synecdoche for a larger competition among the cybernetic and mathematical economists on one side and state planning agencies and party leaders on the other. Both economic planners and party leaders advanced arguments for and against the computerization and networking of the command economy in terms of whether technocratic reform would lead to the proper control over information. Kovalev, together with his cybernetic colleagues and allies, saw in the networked computer a grand manipulator for transforming the economy as a giant information system in need of optimization, objective planning, and diminishing bureaucratic overhead costs. Curiously, the most influential opposition to such proposals came from the main planning state agencies, including Gosplan, the Central Statistical Administration (CSA), Gossnab, and regional and branch committees. These groups openly resisted his and similar proposals because they were perceived to involve personal loss of control over the information in the command economy.

Conclusion

By 1963, with three national network proposals already on the table—Kitov's EASU, Kharkevich's ESS, and Kovalev's unabbreviated "rational system of economic control"—the institutional landscape was evolving toward some kind of head in economic reform. That intellectual terrain includes various supplemental network projects that promoted the core Soviet cybernetic instinct that large-scale information systems, such as the command economy, can become self-sustaining and even self-governing systems. It may be helpful to distinguish between two meanings of the word *automated*—(1) having operations that are entirely independent of human involvement and (2) having operations that are designed to receive and interact with humans but do not necessarily need human involvement. The OGAS, understood as an explicitly cybernetic human-computer interface, clearly signals the latter sense of the term.[59] In other words, the conceit of cybernetic (human-machine) self-sufficiency was not to imagine a national economy that was independent of any other outside forces but rather to envision a socialist planning apparatus that engaged with the economic body it networked and that, together, would prove responsive, balanced, and self-governing. By contrast, the liberal economists sought a different path to self-governing markets—introducing profit measures into local enterprise accounting while still maintaining basic production guidelines for the overall economy. Both cybernetic and economic liberal reforms reached compromise solutions with the operations of the command economy, just in opposite directions. The cybernetic economists offered a technocratic reform that was meant to work with human administrators and liberal economists—a market reform that was meant to work with command economy guidelines.

These contending approaches came to a head in 1963 through 1965 at the same time as the bumpy transition of state power from Khrushchev to Brezhnev. Because both approaches to reform met with unsystematic but widespread resistance from orthodox economic planners and professionals who were comfortable in their current positions, both produced tentative heirs to the economic debates in the early-mid 1960s—the OGAS proposal in 1963 and the Kosygin-Liberman reforms of 1965. Early Soviet networked computing culture was decentralized in practice, despite the state's centralized design in principle. Kitov's EASU first proposed having technomilitary networks be put to public and social benefit, but he found himself grounded for attempting to bridge the yawning military-civilian divide. Three years later, Kharkevich's ESS, with Kovalev following suit, reached ever further, networking all technical signals into a network resembling the pyramidal state while staying silent about any social ambitions. Yet these early proposals fell prey to strategic veto points in the state administration that depended not on bureaucratic rules but on charismatic leadership and personal power. The technical open-endedness of Kharkevich's ESS probably most closely resembles that of the ARPANET, although the ARPANET began with the modest goal of scientific data exchange and the ESS, like the others, began with an ambitious blueprint for an entire digital nation. Unsurprisingly, the more ideologically charged economic networks faced more ideological opposition, and the fate of the ESS points to the charismatic actor-dependent institutional disorder that governed the Soviet knowledge base.

Perhaps the signal lesson to take from these early Soviet network proposals is that there is no inherent connection between the designs of technological and political systems. Many digital theorists in liberal democracies have imagined the effects of technology in the terms of their local political systems, claiming that digital technologies must be deliberative, direct, and participatory—similar to that of contemporary democracy discourse. So, too, did these Soviet cybernetic theorists imagine that a nationwide computer network would "naturally" map onto the design biases and design logics of the formally top-down centralized administrative hierarchy of the Soviet state. Both visions are theoretically imaginative because they neglect actual political practices and their significant costs and consequences. These network proposals ignored the informal, nonhierarchical functions of the Soviet state and society, just as modern democracies involve far more than just the representation of individual voices celebrated by many digital media theorists. Centralizing computer networks and centralized socialist states have as little to do with one another as the digital does with democracy. Both propose imaginatively rich associations about what could be, promising no less than some pseudo-automatic or pseudo-democratic form of self-determination, but do little to affect careful or accurate assessments of how politics actually works on the ground.[60]

These waves of cybernetic imagination about the fit between computer network and formal state and social structure repeatedly broke against the rocks of widespread practice that countered the official Soviet imagination of itself. Paul Baran struggled to secure institutional support from American corporations and a state that refused to recognize the value of what became the key network innovations of his age. So, too, in Moscow, Kitov had to abort the EASU due to his unsuccessful attempt to bridge the abyss that separated military and civilian research, Kharkevich's ESS collapsed with the health of the man appointed to steer its grandiose technical ambitions, and Kovalev's "rational system" fell short of convincing his colleagues in economic administration that ceding their own decision-making power to automated computers could either rationalize or systematize the work of economic planning. All four of these early network projects—three in the Soviet Union and one in the United States—did not take shape due to an imagined and often misleading connection between political and technical systems. All four rooted their imaginations in the explicitly cybernetic terms of analogizing across technological and social systems. This imaginative and at times utopian instinct for political-technological system analogs leads theorists to neglect the significant costs and consequences that come from actual political practice. As it often happens, the revolutionary reach of our modern technological imagination of large-scale networks (among other things) often ends up serving local institutional self-interests and the status quo. The next chapter extends and complicates this theme in its history and analysis of the central and longest-lasting attempt to network the Soviet Union.