CHAPTER FIVE
Moving Information in the Twenty-First Century City

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A Brief History of Teleports

The teleport concept emerged in the early 1980s as a strategy for aggregating telecommunications traffic and transmission facilities for an entire city or metropolitan area. Teleports were positioned to provide global connectivity to regional and metropolitan fiber optic distribution networks. The economics of high-speed, international telecommunications in the early 1980s, when the teleport concept first emerged, were characterized by extremely high fixed costs—satellite ground stations, in particular. As Hanneman explained:

> A teleport is analogous to an airport in many respects. Airports function as air travel centers where costly resources, such as runways and control towers, are shared among all of the air carriers within a given geographic region. Airports are surrounded by a protected airspace, which is kept free of obstructions that could disrupt operations. Travelers have access to multiple carriers at one central location. Aside from efficiently serving the needs of both providers and users of services, land use is maximized for the purpose of air travel (Hanneman 1985:6).

Thus, the teleport was envisioned as a regional gateway to a network of global satellite telecommunications, in the same way that an international airport both enables and symbolizes a region's connections with the global system of air transportation. The World Teleport Association still promotes the view of the teleport as a central metropolitan gateway today:

> Teleports are the "intermodal hubs" of the broadband world—gateways that connect satellite circuits with terrestrial fiber optic and microwave circuits. Bridging the gap between land and sky…they have pioneered in the export and import of the weightless cargo of information (World Teleport Association 2000).

Teleports attracted the attention of many regional planning organizations, local governments, and economic development agencies. They were seen as both a necessary amenity for international business, and a symbol of local technological sophistication. By 2000, approximately one thousand teleports were in operation around the world, with more than one hundred new teleports becoming operational each year.

The archetypical teleport, a joint venture of the Port Authority of New York and New Jersey, Merrill Lynch, and Western Union, is located in New York City. This facility is located on 350 acres of land in Staten Island and features both satellite uplinks as well as co-located office space, primarily for use as back office and data processing centers. Construction began in 1983, with 17 satellite earth stations, 200,000 square feet of office space, and regional fiber optic connections to Manhattan, Brooklyn, Queens, and New Jersey (Moss 1988).

Dispersing the Hub: Regulatory Reform and the Proliferation of Telecommunications Infrastructure

As television production grew rapidly during the 1980s, teleports were highly successful, spurred by an increasingly visually oriented society and the rapid spread of cable television. Always the mainstay of teleport use, broadcast video still accounts for 80–90 percent of commercial teleport revenues throughout the world (World Teleport Association 2000).

Despite the success of teleports in the broadcast market, they were ill-positioned for the next cycle of innovation in the telecommunications sector. The real growth in telecommunications activity during the 1990s was in three areas where teleports typically did not play a major role: long-distance telephony, personal mobile communications, and packet-switched data networks (i.e., the Internet). Thus, while teleports continued to play a crucial role in supporting broadcast video (and this important function has sustained their existence), they no longer dominate the vision or reality of metropolitan telecommunications infrastructure as they did just 15 years ago. Instead, teleports have been relegated to a single niche market (and now a relatively slow growing one) in an increasingly varied telecommunications sector. As the World Teleport Association reports, Intelsat's satellite traffic has grown at an average annual rate of just 3–10 percent for decades.

Urban telecommunications infrastructure is now characterized by a much more widely diffused set of access points to global connections. An equally varied array of new infrastructure systems has been developed and deployed to support these activities. Unlike the teleport model, which linked a single dominant metropolitan gateway to regional distribution systems affordable only to large businesses and institutions, new infrastructure systems provide cheap and reliable high-speed data communications to a broad variety of customers. Furthermore, while competition has fostered much duplication of infrastructure, this has resulted in decentralization and redundancy, resulting in a more flexible, resilient communications infrastructure.

We categorize the components of this new information economy infrastructure through analogies to the infrastructure of the industrial economy. Four components make up this system. *Information highways* include the fiber optic lines and wireless networks that provide local, national, and global linkages between a rapidly growing number of urban telecommunications sites. These sites, the *information factories*, now range in size from the individual using a mobile telephone to the corporate campuses of Silicon Valley. The largest information producers often house their data distribution in dedicated spaces we call *information warehouses,* also known as data centers or server farms. Finally, the entire grid is stitched together at centrally located *information ports,* where competing carriers meet on an equal basis to gain the economies of interconnecting their networks and users.

Information Highways

While the "information superhighway" cliché has vanished from everyday use, fiber optic networks increasingly resemble the nation's road network and the paths they follow to connect distant cities to one another. Within urban neighborhoods and metropolitan areas, fiber optic networks are built along existing corridors of transportation and economic activity. This section describes the development of fiber optic networks at three scales—long-haul (intercity), metropolitan, and central business district.

Long-Haul Networks

Historically, the development and growth of telecommunications has been driven by military applications. Even the Internet had its origins in the Defense Department's Advanced Research Projects Agency. However, in civilian applications, the financial services industry is largely responsible for deciding where the latest communications technologies will be deployed. As a result, there is an extensive network of undersea fiber optic cables linking London and New York across the Atlantic and Tokyo and the west coast of the United States across the Pacific. The paths of the new data infrastructure closely follow well-traveled routes. Worldwide capacity on international undersea cables increased some 225 times between 1990 and 2000 (Telegeography 2000). Global financial centers like New York are the primary landing points for these undersea cables, where telecommunications carriers can offer the best connectivity to major investment banks and can link into domestic telecommunications grids.

Long-haul networks also operate over land in both North America and Europe. According to the Federal Communications Commission, major long-distance fiber networks in the United States built by AT&T, MCI-Worldcom, Sprint, Qwest, Williams, and others grew from 2,085,000 fiber-strand miles to over 3,500,000 miles between 1990 and 1998 (Federal Communications Commission 2000).[1] Furthermore, it is estimated that private firms spent $17 billion on new long-haul network capacity in 2000 alone, and will invest $30 billion in 2002. (Given recent trends in the fiber-optic industry, however, this projection is greatly exaggerated.) Because the FCC does not require carriers to report the activation status of these strands, nor the type of signaling equipment used, there is no data available on the growth of actual network capacity or usage.

[1] *A fiber-strand file indicates a single optical fiber running for one mile. Other commonly used measures of fiber deployment are the sheath mile and route mile, which offer no indication of potential transmission capacity.*

Contrary to pundits' hype about the "death of distance" caused by a proliferation of telecommunications capacity, the cost of leasing bandwidth is still very sensitive to distance and capacity. Table 1 shows the per unit price for one megabit per second of data transmission capacity for one year from New York City to destinations throughout the world.[2] Domestic rates are the lowest due to extensive competition along domestic routes and a lack of international tariffs. To the United Kingdom and Ireland, where telecom markets have widely opened in recent years, prices are slightly higher. To the European continent and Asia, prices rise dramatically as regulatory barriers and large geographic distances come into play.

Table 1 *Sample Bandwidth Rates from New York City*

Destination	*Capacity**	*Per Unit Price ($ per Mbps per year)*
Washington	2.5 Gbps	148
Washington	622 Mbps	401
Washington	155 Mbps	564
London	2.5 Gbps	1,162
London	155 Mbps	2,323–2,510
Dublin	2.5 Gbps	5,250
Dublin	155 Mbps	5,758
Paris	155 Mbps	10,510
Frankfurt	155 Mbps	10,510
Milan	45 Mbps	12,222
Vienna	45 Mbps	16,222
Prague	45 Mbps	16,222
Tokyo	45 Mbps	40,644
Hong Kong	2 Mbps	144,640

*1 Gbps (gigabits per second)=1,024 Mbps (megabits per second)=1,048,576 Kbps (kilobits per second). 1 Gbps is approximately 19,750 times the capacity of a typical 56 Kbps dial-up modem connection.

Source: Authors' calculations based on wholesale bandwidth offers on Band-X (2000a).

Like the undersea cables—which follow routes that date back to the days of Clipper ships—continental long-haul networks are following and reinforcing existing urban networks in many ways. Just as the Interstate Highway System followed the interurban

[2] *1 Mbps is approximately the amount of bandwidth used by 16 voice circuits.*

routes first pioneered by railroads, optical fiber is piggybacking on existing infrastructure systems and following existing corridors of economic activity. Qwest's national optical network is primarily laid along train tracks, and rail-mounted vehicles were used to install the cable. In the densely settled Northeast, the bulk of long-haul fiber is laid down along interstate highways and toll roads. Metropolitan Fiber Systems, now a subsidiary of MCI/Worldcom and an early builder of metropolitan networks, has its roots in Able Telecom. Able was the contractor for data networking for the Northeast Corridor's EZPass automated highway toll collection system in the 1980s. New York and Los Angeles have both received proposals to deploy fiber in subway tunnels and high-pressure water mains.

Metropolitan Networks

Within urban regions, extensive metropolitan fiber optic networks were built over the last fifteen years by local Bell telephone companies to connect neighborhood-level switching centers for voice and (more recently) data traffic. Between 1985 and 1998, local telephone companies deployed over 15,000,000 miles of fiber strands, far greater than that laid for long-haul networks. More than half of this capacity was deployed in just five years between 1993 and 1998 to accommodate explosive growth in demand for additional phone, Internet, and fax lines (FCC 2000).

Competitive Metropolitan Area Networks (MANs) emerged in the late 1980s as businesses seeking data transport among branch offices found Local Area Networks too small and Wide Area Networks too large for "a modest community of users within a 50-kilometer diameter" (Morreale and Campbell 1990). More recently, a new group of firms has entered the metropolitan fiber optics market, greatly increasing the amount of fiber capacity linking regions into a cohesive unit. These include firms such as MetroMedia Fiber Networks (MMFN), which has deployed so much capacity it is now a supplier of capacity for the traditional local telephone company, Verizon. In turn, Verizon has now acquired a stake in MMFN.

The metropolitan component of the information highway will likely take as long to build as the transcontinental and undersea grids, which were begun in the mid 1980s. According to Stephen Garafalo, MMFN's founder and CEO, "Unlike the long-haul networks that are [going to be] built in just a few years, the infrastructure that controls 80 percent of the data market worldwide is within the local loop. Many of these metropolitan areas of major cities will take 15–20 years to build out by the time it is completed" (Global Telecoms Business 1999).

However, while metropolitan networks are both massive and rapidly changing, there is very little understanding of this telecommunications infrastructure among local planners and policy makers. One notable exception is Atlanta, where the Metro Atlanta Chamber of Commerce (MACOC) has partnered with the Georgia Center for Advanced Telecommunications Technology to publicize maps and data on the region's telecommunications assets. This information has proven to be a valuable tool in luring high-technology and information-industry firms to the region (MACOC 2000).

Central-City Networks

High-capacity fiber optic networks have been deployed in every major downtown in North America. Most cities have several competing providers—even medium-sized cities such as Portland and Cincinnati have two dozen or more fiber optic networks tracing their downtowns. Philadelphia has at least a dozen. More prosperous cities such as Atlanta, Dallas, and Denver—home to many information-based businesses—may have more than thirty. In major centers of finance such as New York or San Francisco, an unknown number of networks lace the city's streets.

The specific routing of these networks is well-protected, proprietary information. One study in San Francisco in 1996 attempted to map fiber optic networks by analyzing street cut permits. That effort was thwarted when a group of telecom companies working in the study area sued for an injunction to prevent public access to the permit information. More recently, the Center City District in Philadelphia has taken a creative approach to mapping that city's telecommunications infrastructure. According to Executive Director Paul Levy, when telecommunications companies refused to share information on routes, he relied on building permits and city council ordinances authorizing related construction and street cuts to reconstruct the routes. The result (see Figure 1) is one of the few insights available into the aggregate impact of these competing infrastructures on urban cores. City fiber networks have short, highly selective routes that are designed to access the most lucrative corporate customers in a given city. MCI/Worldcom's 125 km-long fiber ring in central London carries some 20 percent of the U.K.'s international telecommunications traffic (Graham 1999).

Information Factories

The need for information highways is driven by the production and consumption of information in the nation's *information factories*—the wired office buildings and homes where the bulk of data sent over telecommunications networks begins and ends its journey.

In the United States and elsewhere, commercial office buildings are now highly wired factories for the production of information products. One study has estimated the market for communications equipment and services in multi-tenant office parks will rise to over $2 billion in 2004, from $371 million in 2000.

In New York City, one firm has been responsible for connecting a large number of office buildings to the Internet. Intellispace has wired hundreds of buildings in Manhattan and the surrounding metropolitan area. Figure 2 shows buildings in Manhattan that have been wired for broadband Internet access by Intellispace. Using a high-speed fiber optic infrastructure, Intellispace offers clients broadband Internet for slightly under $1,000 per megabit per second (Mbps). Clients can purchase Internet connections at speeds of up to 1,000 Mbps (1 gigabit per second) (McCarthy 2000). Intellispace and competitors such as Allied Riser Communications, Urban Media, and Eureka Broadband are now known as building local exchange carriers (BLECs).

Source: Center City District, Philadelphia, PA

Figure 1 *Fiber Optic Cable Layout in center city*

The demand for wired office space is enormous. In major metropolitan areas, office buildings can no longer attract the best tenants without offering sophisticated telecommunications facilities. Jennifer Zeller, Research Manager for the Metro Atlanta Chamber of Commerce, is responsible for understanding how firms select regions and buildings in which to base their operations. Based on her experience in the last few years in booming Atlanta, she notes that, “Up to half of all office prospects we talk to express a need to have fiber service.” Zeller concludes, “It’s almost a given these days that office operations have access to fiber service.

Wired Office Buildings

Figure 2 *Buildings in Manhattan Wired by Intellispace Corporation*

Wired Homes

Homes are also rapidly being integrated into America's broadband information infrastructure through new high-capacity technologies such as Digital Subscriber Lines (DSL) and bi-directional cable data networks. Homeowners are increasingly integrating several computers in their homes through Local Area Networks. Although it is not clear whether local networking within the home will best be achieved through wired technology, the home's main broadband data connection to the larger world—just like the office—will be a high-bandwidth wire.

The so-called "last mile" of the Information Superhighway—from neighborhood switching centers to consumers' homes—has been the greatest obstacle to broad-based broadband deployment during the 1990s. However, as surveys by the Federal Communications Commission indicate, broadband service is now starting to reach a significant number of homes. According to one study, by the end of 1999 nearly one million homes subscribed to either cable or DSL service, a three-fold increase from the end of 1998 (FCC 2000). Although there have been installation difficulties and delays in many areas of the United States, subscriber growth rates are expected to remain very high for the next decade.

Information Warehouses

While the information that is critical to the economic and social lives of cities is created and consumed in information factories, intermediate points of storage and distribution of information are required, just as the industrial age needed warehouses for the storage and distribution of goods. Commonly referred to as "Internet data centers" or just "data centers," information warehouses offer secure, climate-controlled environments for locating computer equipment such as Web servers and mass storage devices.

Data warehouses also provide access to high-capacity Internet backbone networks through a variety of service models. Warehouses either a) contract with a single carrier to provide capacity to all tenants, b) invite a carrier to serve the facility and negotiate with tenants individually, or increasingly, c) provide national or global backbone services themselves. In this sense, the firms that build information warehouses operate more like a shipping company than a port authority. They are actively involved in the transcontinental transport of data among their clients' servers, which are located inside one or more of their information warehouses.

Information warehouses are less tied to central urban locations than information ports, which are discussed in the next section. As distribution centers, they are also more closely tied to consumer markets than producer markets. As a result, they are beginning to trickle down into the second- and third-tier cities of North America. In these locations, the demand is not for competing carriers offering the most advanced services to major corporations, but rather simple distribution points for Internet content to large media markets.

San Francisco, New York, and Washington, the nation's three primary Internet hubs, lead the nation in information warehouse development. Los Angeles and Boston form a second tier, followed by Chicago, Dallas, Atlanta and others. Table 2 shows the top twenty foreign and domestic metropolitan markets, which accounted for over 90 percent of all data centers in the world during the summer of 2000. While new data centers were being considered for medium and smaller metropolitan areas, catastrophic contraction in the market for these facilities had shelved these plans as of the middle of 2001.

So while information warehouses are not as tightly bound to the existing infrastructure grid as some other new telecommunications facilities, and thus have more locational freedom, they still need to be in general proximity to their clients. As U.S. Dataport executive John Mognannam put it:

> You need to be in the proximity of those who own and use the servers, preferably within about 20 minutes to a half-hour, so that if there's a problem, the user will be able to reach the [information warehouse] very quickly (Martin 2001).

Table 2 *Internet Data Centers by Metropolitan Area*

Region	*Data Centers*
San Francisco/San Jose	42
London	35
Washington, D.C.	28
New York	26
Los Angeles	22
Tokyo	18
Amsterdam	17
Boston	15
Hong Kong	14
Stockholm	12
Chicago	11
Dallas	11
Atlanta	10
Seattle	9
Denver	7
San Diego	6
Phoenix	5
Columbus	3
Houston	3
Miami	3

Source: Stratsoft, LLC (Concord, MA)

Information Ports

The final, and possibly most important part of the new metropolitan communications grid is the carrier-neutral, co-location facilities, or *information ports*. Commonly known as "telecom hotels," "carrier hotels," or "telehouses," these buildings are third-party locations that provide a centralized meeting point for telecommunications carriers and their clients.

The information port is a very new component in the nation's telecommunications infrastructure. In the past, new telecommunications carriers would typically lease space in a facility owned and operated by AT&T or a local Bell Telephone company. Following the explosion of competition in the telecommunications sector after deregulation in 1996, this arrangement fell apart for two reasons. First, the incumbents' facilities were notoriously small, substandard, and unsecured, and could not meet the huge demand for co-location space. Secondly, there was a serious conflict of interest for start-up carriers in co-locating in their main competitor's facilities.

Information ports provide a venue for network interconnection among different telecommunications carriers. The value of large inter-connected networks like the Internet comes from the huge number of potential contacts that can be reached. But carriers need to physically interconnect their networks in at least one point in order to realize these gains, and to do it efficiently they need to connect in many places (i.e., East Coast, West Coast, etc.). The neutral status of co-location facilities makes them an ideal place for major carriers to interconnect their networks. In this role, information ports serve a similar role in the information city that ports and railroad terminals served in the industrial city.

The clustering of carriers also creates a privileged space for co-location of servers and other data distribution equipment—far more than those of remote information warehouses served by one or two carriers. In addition to carrier co-location, most information ports also provide secure, climate-controlled, disaster-proof environments for advanced telecommunications and computer equipment, with redundant systems for electrical power and telecommunications.

Co-location allows carriers and tenants to outsource facilities management. They also relieve rapidly growing telecommunications firms of the burden and liquidity problems of real property ownership. Information ports offer state-of-the-art infrastructure systems for mission-critical telecommunications and computing equipment. Tenants require very high standards of security (24 hours/7 days), electric supply (grid plus diesel backup with on-site fuel storage), air-conditioning, and fire-suppression. Premium facilities now feature Kevlar-lined walls, a response to the 1996 IRA bombing of London Docklands that caused millions of dollars in damage to computer systems and lost data. Additionally, in earthquake-prone regions along the Pacific Rim, seismic reinforcement is a critical requirement. Finally, to avoid disconnection from the communications grid due to accident or sabotage, multiple routes into the building for fiber optic lines must be provided.

By 2000, over 20 million square feet of information port space had been built out around the world. Yet much of this was speculative and by 2001–2002 it was clear that there was an excess of capacity. While information ports remain in operation and are key to the functioning of global telecommunications networks, their once-rampant growth has slowed to a crawl, and they are being absorbed into the larger urban fabric. It is unlikely that significant expansion of these facilities will occur until the excess capacity has been absorbed over the next 5–10 years.

Until very recently, co-location facilities were largely concentrated in the world's financial capitals—New York, London, and Tokyo. There, they supported the early growth of competitive telecommunications carriers targeting the concentrated markets of their great financial districts. However, the rapid recent growth of the Internet and the evolution of content distribution networks has greatly increased demand for information ports in many more metropolitan areas.[1]

Surprisingly, however, the vast majority of information ports are located in or nearby downtown central business districts. This is in contrast to the network interconnection points set up by the National Science Foundation when the Internet was privatized in the early 1990s. Of the four original interconnection sites designated by the NSF in the early 1990s, only one (the Ameritech NAP in Chicago) was located in a central city. Most were at the far fringes of their respective metropolitan areas.[2]

Not surprisingly, lease rates for space inside information ports are mostly determined by local real estate markets, rather than trends in the technology industry. During the peak of the American technology bubble in 2000, a general shortage of commercial space combined with strong demand for colocation to drive information port space to a premium. As Table 3 shows, in late 2000 information port leasing fees were well over $500/month for a standard equipment rack. This was the equivalent of two to three times the price of regular commercial office space. At the time, prices were rising as much as 40 percent every six months (Band-X 2000b, c). Needless to say, the potential for such premium rents lured many speculators, and overbuilding was the inevitable result. The dot-com bust in 2000 cost these facilities many of their most lucrative tenants.

The New Metropolitan Grid

In this chapter, we have outlined the evolution of a new metropolitan grid—the vital production, transport, and storage infrastructure that supports the Internet and other modern telecommunications networks. Through decentralized market forces, tens of thousands of private systems have been stitched together to create a highly flexible, redundant system with greater coverage, capacity and usefulness than ever before. Figure 3 shows how these systems are situated with respect to each other and the urban geography of metropolitan regions.

[1]Content distribution networks cache multimedia content for Web pages in locations closer to end users. This dramatically speeds end-user performance, compared to serving the content from a single central server.

[2]Of the four Network Access Points (NAPs) designated by the National Science Foundation in 1992, only one, the Ameritech NAP in Chicago, was located inside the boundaries of a central city. The other three—MAE-East (Vienna, VA), Sprint NY NAP (Pennsauken, NJ), and PacBell NAP (San Ramon, CA)—were all located well away from central cities in suburban office areas, so-called "edge cities."

***Table 3** Information Port Monthly Leasing Rates by City Standard Server Rack, 3Q2000*

City	*Lowest*	*Highest*
United States		
Chicago	$1,000	$1,300
Cleveland	700	1,000
Dallas	800	1,300
Los Angeles	400	1,300
New York	750	1,300
San Jose	550	900
Seattle	900	1,000
Europe		
Amsterdam	$750	$1,000
Dublin	1,000	1,130
Frankfurt	230	630
London	400	1,000
Paris	500	670

Source: Authors' analysis of lease offers posted on Band-X.com

In this framework, information ports form the core of a meshed, redundant fiber-optics infrastructure that provides connectivity both within the region as well as long-haul intercity service. From this centrally located interconnection complex, located near the largest information factories (corporate office buildings), smaller information highways distribute information to exurban information warehouses and clusters of residential neighborhoods using broadband or dial-up Internet access.

Winners and Losers in the Spread of New Telecommunications Infrastructure

The patterns of infrastructure development described above indicate that access to advanced telecommunications services is indeed decentralizing within American cities. While in the 1980s only the wealthiest institutions like investment banks could afford high-speed telecommunications services delivered from centralized facilities, today a broad range of firms and individuals have access to cutting edge infrastructure and services. However, the differences among cities reflect much greater variations, as seen by the distribution of Internet data centers. Indeed, a strong, place-based "digital divide" that rivals those based on gender, race, and income exists. More importantly, this place-based divide has been remarkably resistant to change and, in some fundamental aspects, may actually be increasing the economic divide between prosperous and ailing regions.

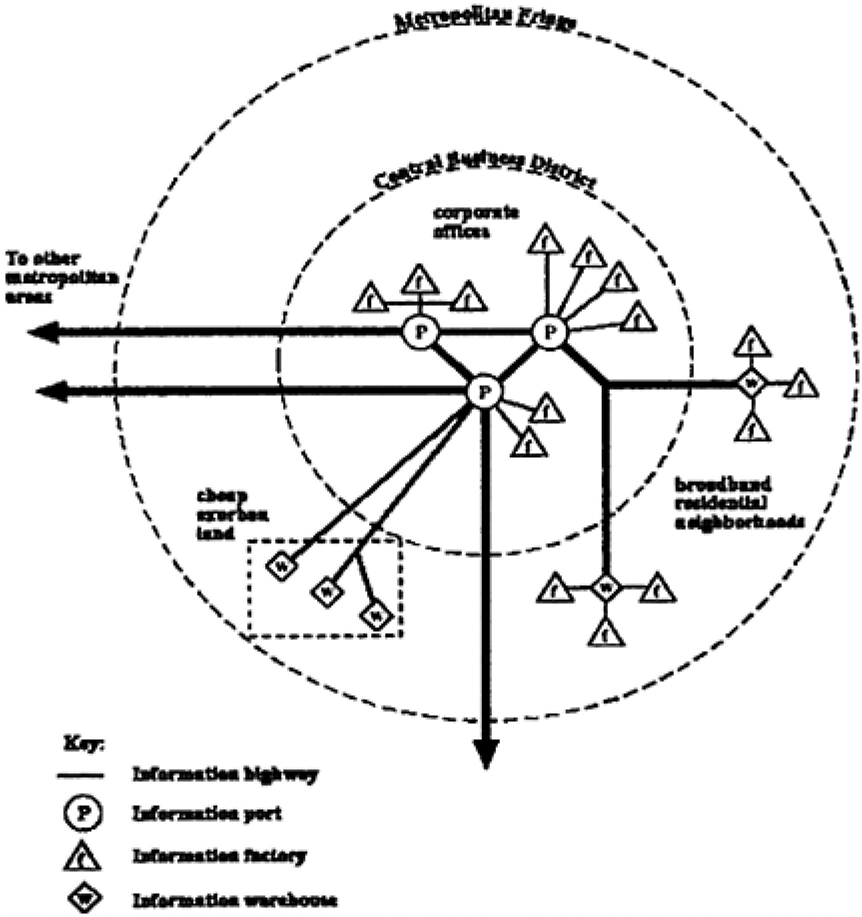

Figure 3 *The New Metropolitan Communications Infrastructure*

In many instances, adequate physical telecommunications infrastructure is in place, but markets have not emerged to utilize this capacity or foster its interconnection with other metropolitan regions. Thus, it seems clear that the linkage between telecommunications and economic development is not one-to-one. Telecommunications infrastructure can make competitive places globally competitive, but can never make uncompetitive places competitive. Telecommunications infrastructure cannot be perceived as a redevelopment strategy in and of itself. It can play a role in supporting other efforts, but without adequate human resources and institutional support, it is insufficient to stimulate growth. This mistaken emphasis on physical infrastructure is still deeply rooted in the urban planning community, despite many efforts to broaden thinking about urban problems over the last four decades.

Epilogue: Urban Communications in the Age of Terrorism

The terrorist attack New York suffered on September 11, 2001 highlighted many aspects of the new communications infrastructure described in this chapter. Verizon's local telephone network suffered extreme damage, in large part because operations had been highly centralized in just a few key buildings. One such building, 140 West Street, housed four central offices serving over 3.5 million voice and data circuits. Following damage sustained during the collapse of the World Trade Center towers and the subsequent firefighting, the facility had to be completely reconstructed.

In contrast, the distributed infrastructure of the Internet performed remarkably well. Despite a significant multi-day power outage at Telehouse, a major information port in Lower Manhattan, Internet performance and connectivity in New York City and the surrounding region was almost completely unaffected. Throughout that terrible day, for many, e-mail proved a more reliable means of reaching friends and family than telephones. The Web provided in-depth news coverage and emergency information, even while broadcast antennas lost in the collapse had shut off television coverage for millions.

The ideas about distributed networking that have driven the development of packet-switched data networks like the Internet since the early 1960s have turned out to be prescient. While these ideas were born in an earlier era of fear and crisis, we are fortunate enough to benefit today from the reliable communications they have brought to reality.

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