

Designing the Digital City

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Abstract. The forms that cities take, the ways they function, and the mixes and distributions of activities within them have always been influenced very strongly by the capabilities of their underlying network infrastructures. Furthermore, cities have often been transformed by the introduction of new infrastructures. It is impossible to imagine Rotterdam without its canals and connection to the North Sea, Chicago without its railroads, Los Angeles without its freeways, or any large modern city without water supply, sewage, electrical, and telephone networks. Today, a new type of network infrastructure — high speed digital telecommunications — is being overlaid on cities everywhere. Its effects will be at least as revolutionary as those of the new network infrastructures of the past. It is already causing traditional building types and neighborhood patterns to fragment, recombine, and form startling new arrangements. This process will continue and accelerate. In this paper I describe the new digital infrastructure, analyze its major spatial effects, consider some illustrative examples of the resulting fragmentation and recombination, and discuss possible design responses with particular attention to social equity and long-term sustainability.

Digital cities are being developed all over the world. Digital cities integrate urban Let us ask some fundamental, practical questions about the role of digital telecommunications and ubiquitous computation in shaping our future cities. What new opportunities do these technologies provide to produce cities that are attractive, equitable, and sustainable? What unwanted side-effects must we contend with? And what strategies should architects, urban designers, and urban planners pursue to take maximum positive advantage of the potential benefits while avoiding the possible downsides?¹

Network Infrastructures

We can best approach these questions, I believe, by reflecting upon the roles of earlier network infrastructures — water supply and sewer systems, streets and roads, canals, railroads, electrical grids, telegraph, telephone, and broadcast systems — in forming urban structures and patterns. Most obviously, these networks augment the

¹ These strategies are discussed in more detail, with extensive supporting documentation, in William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (MIT Press, 1994), and William J. Mitchell, *E-topia: Urban Life, Jim — But Not As We Know It* (MIT Press, 1999).

affordances of the places they serve, and so support activities that would not otherwise be possible there. Furthermore, they allow greater concentration of human activities by connecting urban locations to distant hinterlands.

Thus, for example, a piped water supply system allows habitation of sites that would otherwise be too barren to support life. And, by drawing upon a far-flung catchment area, it can support a much greater population than local water resources would otherwise allow. Similarly, sewer systems disperse waste that would otherwise accumulate locally, road systems allow trade with the food-producing countryside and other cities, electrical supply systems mitigate the effects of darkness and climatic extremes, and so on.

We have to consider not only the immediate effects of particular networks, but also the ways in which multiple networks interact to produce joint effects. An irrigation network might allow a desert location to produce crops, for instance, but it is also necessary to have road or rail access to get those crops to market. Water supply and transportation networks may allow population to concentrate at a location, but this population will not be sustainable unless there is also effective waste removal.

As geographers and planners have long-since discovered, the interactions of these networks with patterns of land use are complex. On the one hand, construction of networks creates the possibility of new land uses at the locations served. On the other, existing land uses generate demands for network service. Urban spatial development is best understood, then, as a recursive process, unfolding over lengthy periods of time, in which network infrastructures and land-use patterns evolve by continually responding to one another.

When a new type of network infrastructure emerges, it is not deployed across homogeneous terrain; it is overlaid on a spatial pattern that has developed in response to its predecessors. Typically, by creating new relationships among existing activities and introducing new activities, new network infrastructures produce significant transformations of such existing patterns. Since the industrial revolution, in particular, we have seen the effects of overlaying modern transportation, electrical supply, and telephone systems on older urban fabrics. Conversely, we have also seen the effects of removing network infrastructure or getting bypassed by it; there are numerous sad examples of towns and cities that have declined when railway or riverboat service ceased, or when interstate highways passed them by.

What, then, are the effects of overlaying digital telecommunications on existing urban patterns? How will this new type of network interact with existing ones? And what sorts of transformations can we expect to result?

Fragmentation and Recombination

The basic function of digital telecommunications, of course, is to allow human interaction at a distance. To the extent that remote interaction successfully substitutes

for face-to-face, traditional requirements for adjacency among activities — the bonds that have always held buildings, neighborhoods, and cities together — are eliminated. However, only some — by no means all — such bonds are loosened or removed. You may now do your banking remotely, for example, thus eliminating the need for face-to-face interaction with a teller at a local branch bank. But, if you want to get your hair cut, you still need to go to the hairdresser's for a face-to-face interaction. The net effect is neither decentralization of everything nor rampant centralization (as some early commentators had suggested), but a complex process of fragmentation and recombination of familiar building types and urban patterns. It is much like a chemical reaction in which some bonds are broken, others remain, new ones form, and a new compound — with interesting new properties — results.

Consider, for example, the now-familiar effects of online bookselling. By making use of Web sites instead of traditional sales floors, online book retailers such as Amazon.com radically decentralize the activities of browsing and purchasing; instead of taking place in a few retail establishments at central locations, these activities are distributed to Internet-serviced desktops in huge numbers of homes and offices. The space to accommodate these activities, which had once been grouped with other retail space, now fragments and recombines with domestic space and work space. At the same time, book storage and distribution functions equally dramatically centralize. They no longer need to be clustered with browsing and purchasing, as in a traditional bookstore, but are now performed at a few national centers located at convenient air transportation hubs; this allows both economies of scale and maintenance of much larger stocks than are possible in scarce and expensive urban retail space. And back-office functions such as billing and stock control, which reduce to manipulation of digital data, no longer need to near either the books or the customers, and can float free to wherever teleworkers are available at a price the management is willing to pay.

There are implications not only for location of activities, but also for transportation demand. With old-fashioned bookstores, books were delivered in bulk to the stores (that is, to intermediate storage points), then carried away by purchasers. With online bookstores, the emphasis shifts to express package delivery from the national distribution center to widely scattered homes and workplaces.

You can carry out this sort of analysis for just about any of the emerging online retailing or service industries, and the results vary according to the natures of the particular products or services offered. Books are small, high value, imperishable, and a delivery time of a day or two is generally acceptable, so national distribution centers make sense. The same goes for music CDs, videos, consumer electronics, and many drugstore items. But groceries are bulkier, less valuable, and more perishable, so they demand regional distribution centers rather than national ones, and fleets of specialized local delivery vans rather than national package express systems. Hot pizzas are even more perishable, and require nearby local production and distribution centers. On the other hand, computer software, digital music recordings, and digital videos can be delivered online (provided that the bandwidth is sufficient), so the distribution centers can be located just about anywhere there's good network service, and telecommunication does not just restructure transportation requirements but completely substitutes for transportation.

Finally, we should not forget that delivery points for products and services — homes and workplaces in particular — are likely to change in response to their new roles within these systems. At the very least, they need network connections for placing orders; today, these typically take the form of PCs running Web browsers, but we are likely to see increasing use of smart appliances and closets that electronically order their own supplies, and sensor-equipped spaces that can summon medical and security services. The humble mailbox is likely to evolve into a larger and more sophisticated repository that can keep perishable goods from deteriorating and keep high-value goods secure. And home TVs, VCRs, CD players, radios, and videogame consoles will evolve into much more intelligent systems for finding, ordering, retrieving, organizing, displaying, and paying for digitally distributed entertainment, news, and educational materials.

The Redistribution of Office Work

What happens to office work space under these conditions? Once again, we can begin to discover the answer by disaggregating the functions of a traditional office and considering the differing implications of telecommunications for each one.

Traditional office buildings provide individual workspaces such as private offices and cubicles, convenient access to files and other work materials stored on-site, access also to machines such as copiers and printers, and group work and meeting spaces such as conference rooms and foyers. Access to people and facilities is controlled by receptionists. Layout and circulation are organized for maximum convenience and efficiency of internal interactions. Locations, typically, are in downtowns serviced by transportation networks or in suburban office parks with convenient automobile access. Each of these characteristic features is affected differently by digital telecommunications, so that office space also fragments, redistributes itself, and recombines with other activities rather than simply relocating.

First, in the era of the networked laptop computer, email, and sophisticated telephone services, private work spaces do not need to be grouped together in office wings and cubicle farms; employees can effectively take their private work home, on the road, or to customer or supplier sites. When files are converted to digital form and put online, it is no longer necessary to be physically adjacent to them. Copiers, printers and the like are becoming smaller and less expensive, so it is possible to distribute many of them to scattered locations instead of maintaining a few large ones at central locations. The most obvious results are the home telework space (recombination of office space with domestic space), the hotel room increasingly functioning as work space (and equipped to do so), and the airport lounge and airplane seat as workplaces. Furthermore, the centralized private offices and cubicles that remain may no longer be semi-permanently assigned to individuals, but may be part of a pool for temporary assignment as required.

On the other hand, face-to-face meetings remain crucial for many purposes. Thus office workplaces in central locations are likely to emphasize provision of meeting

space, together with meeting support facilities such as food service and short-term accommodation. And there is likely to be continued growth of short-term meeting facilities at central locations, such as hotel meeting rooms, airport business centers, and convention centers.

Within this new spatial pattern, receptionists can no longer control access to people, facilities, and information in the traditional way, and supervisors cannot perform their functions by means of direct visual surveillance. These functions are largely taken over by software. Instead of having to walk past a receptionist to get to a confidential file, for example, an employee now has to log in to a secure area of cyberspace. When software functions in this way, much of the need to group activities in secure, supervised areas disappears.

Thus, for all these reasons, the adjacency bonds that have held the components of traditional office space together are weakened or broken, and these components can respond to other spatial imperatives. There is much more flexibility in the location of private work, and this allows more of it to take place at home (reducing commuting), on the road (reducing employee down-time), and at customer sites. Simultaneously, central locations and transportation nodes attract face-to-face meeting spaces and associated services, and can achieve economies of scale in provision of these.

Similar analyses can be made of the school, the university campus, and the hospital. Remote access to information resources means that there can be much more flexibility in the location of private study space, and remote monitoring and telemedicine capabilities provide comparable flexibility in sites for many types of medical care. But those aspects of education and medical care that continue to require face-to-face interaction will still tend to gravitate to central locations conducive to economies of scale and efficient provision of related services.

New Homes and Neighborhoods

In the case of residential space, a variety of scenarios — responding to needs of different cultures and subcultures, different segments of the population, and different values and priorities — are likely to unfold. For some of the affluent elite, the loosening of traditional locational constraints will open the way to a footloose existence as electronically connected nomads pursuing business and recreation across the globe. For those entranced by the old dream of rural retreat, it will provide the means to create isolated electronic cottages.

Most interestingly, though, the processes of fragmentation and recombination that I have sketched here will provide opportunities to recreate highly desirable neighborhood patterns that were torn apart in the cities of the industrial era. In these cities, a coarse-grained urban fabric typically developed; workplaces grouped in industrial areas and central business districts, housing grouped in bedroom suburbs, and lengthy daily commutes resulted. Today, when an increasing amount of work is information work that can be electronically supported and flexibly located, it is

possible to recombine the home and the workplace — in many ways, to recreate a pre-industrial land-use pattern in the post-industrial era.

This electronically mediated live/work pattern yields a higher daytime population in residential areas than the commuter suburb, which then has the potential to support neighborhood services such as cafes, health clubs, hairdressers, business centers, child care and elderly care, and so on. These, in turn, provide the opportunity to create lively streets and public spaces. The result — if it's done well — can be an urban fabric of vigorous, pedestrian-scale neighborhoods that take advantage of the affordances of remote electronic connection to produce a high density of face-to-face interactions at the local level.

Kyoto's traditional *machiya*, in fact, demonstrate how this can work. In the *machiya* districts, townhouses accommodate both living space and work space, and there are numerous restaurants, bars and other local service facilities scattered throughout the fabric. The workspace has mostly been devoted to light industrial use, such as textile work. The live/work mix has been reasonably acceptable as long as these uses have not generated too much traffic, noise, and pollution, but it begins to show strain when the typical side-effects of light industry become prominent. This fine-grained mix would function even more effectively if information work, which does not produce the undesirable side-effects of light industry, could be substituted.

This strategy has much in common with strategies advocated, in the United States, by the New Urbanists. But whereas New Urbanist projects frequently rely too much on nostalgic recollection of days gone by — the image of a traditional Main Street rather than a convincing effort to generate the social and economic conditions that could make a Main Street work today — this sort of re-weaving of the urban fabric focuses on creating a robust underlying spatial structure that responds positively to today's emerging realities, and it does not commit designers to styles and images drawn from the past.

Summary: Re-weaving the Urban Fabric

In summary, I suggest that the deployment of digital telecommunications infrastructure creates a radically new logic governing the mix and distribution of living space, work space, and service locations within the urban fabric. The responsibility of urban designers and planners is neither to embrace this new logic uncritically, nor to hunker down in dogged resistance to it. It is, instead, to understand the opportunities that this new logic presents for re-weaving the urban fabric, and thus to find new ways to pursue the ancient goals of equity, sustainability, and delight.