Toward a network-oriented, ICT-based urban planning

Abstract

This chapter focuses on a specific contribution to research on e-planning: the search for new spatial concepts, inspired by ICT. The challenge is to design the 'connected city', launched by the New Charter of Athens. It does not suffice to adopt a New Charter. One must also develop new instruments of design as the instruments, based on the old charter, no longer work today. Urban planning, in order to cope with the problems of today, must be ICT based and therefore be network oriented. To prepare the ground for this, the central concept of network is introduced, a new old way of thinking cities that never made it in mainstream urbanism. This concept is analyzed and applied to the Internet., the most revolutionary form of ICT. But in spite of emergent examples of network- oriented design and of promising avenues of further research, the challenge of network-oriented, ICT- based urban planning – not be confused with the myth of ICT being a simple substitute for cities and urban life – is not yet fully accepted by traditional practitioners or academic planners for that matter. They obviously find it difficult to "organize complexity". This at the risk of further marginalization of urban planning as a discipline and as a practice.

Introduction

We are still more familiar with physical space than with virtual space, both as users and as practitioners of urban planning. Physical space is the material object of urban planning. It comprises, traditionally, zones adapted to certain human activities and channels of communication connecting them and catering to transport. Virtual space, on the other hand, is less familiar. According to Graham (1998) it is nothing more than abstract flows of electronic signals, coded as information, representation and exchange. Virtual space is not bound to a location in physical space. Being less familiar, explains the frequent use of spatial metaphors to describe it, metaphors such as web *site,* electronic *highway* or *city* of bits. Defining physical space and virtual space as distinct entities, avoiding metaphors, one should concentrate on identifying the interactions between the two. The framework shown in *Figure 1* can help to clarify physical/virtual space interaction.

Visualization

Physical space and its design can be visualized in virtual space by using digital plans, maps and pictures, computer animation and the like.

On-line planning/design

On-line planning is an interactive process, involving those for whom the planning is done. It is public participation using ICT tools. This new form of public participation can be impeded by lack of motivation, lack of understandability, and lack of access to ICT (the so-called digital divide).

Analysis

It is about the physical or spatial representation of virtual space. Take for example a network analysis of the Internet. More about this later.

Design

The fact that design has been characterized in figure 1 by an arrow pointing from virtual space to physical space, does not imply that the latter is seen as being simply impacted upon, let alone as being determined by virtual space. Design rather means a search for new spatial concepts, inspired by ICT.

The main purpose of our contribution to research on e-planning is *design.* This is not a theoretical discourse, but rather an attempt to prepare the grounds for new instruments of design. We think that this a matter of network thinking.

It will be shown that network is the central concept that links analysis and design. This to set the stage for a network-oriented urban planning with an emphasis on ICT networks.

The challenge

A new Charter of Athens has been published in 2003, seventy years after its predecessor. The latter has provided the dogma of mainstream urbanism until today. Over the years, however, the world has radically changed (take only the more recent rise of ICT). Mainstream urbanism cannot cope with this as the Charter of 1933 is based on two false premises:

> (a) It is desirable to concentrate functions into giant packages; (b) The geometry within each package is homogeneous. Nevertheless, a city contains so many functions that it is impossible to isolate them. Let alone concentrate them, so that imposing a simplistic geometry on urban form inhibits the human activities that generate living cities. (Salingaros, 2005a, p. 101)

Moreover, giant homogeneous packages– combined with 'automobile dependence' (Dupuy, 2008a) - underlie today's, by and large, unsolved urban mobility problem.

The New Charter of Athens focuses on the connected city:

> The connected city is comprised of a variety of connective mechanisms acting on different scales. These include tactile and visual connections to the built environment, as well as connections between a diversity of urban functions, infrastructure networks, and information and communication technologies. (European Council of Town Planners, 2003, p. 8)

Where exactly does ICT come in? In recent years it has become less of a hype, less conspicuous in most domains of everyday life. Urban planners, however, have difficulties in designing the connected city (there are lesser problems using ICT as a visualization tool). Adoption of ICT in design would have been easier if there would be a direct relationship between the new technologies and physical space. But things are more complex as the focus of understanding cities shifts from their physical structure to the flow and exchange of information. "Information exchange includes

the movement of people and goods, personal contact and interaction, telecommunications, as well as visual input from the environment" (Salingaros & Coward, 2005, p. 172)

Jacobs (1992) has pleaded for treating cities "as problems of organized complexity" (p. 434).(from a book first published in 1961) With ICT, complexity has considerably increased to the extent that it provokes a paradigm challenge for urban planning. How to conceptualize the connected city in order to re-assert the grounding powers of urban planning or urbanism?

Network: the central concept

A first step is to introduce the key concept of network. Urban networks, the ones we are interested in here, have a multidisciplinary theoretical basis. It has been labeled new science of networks by Barabási (2002) which, according to Watts (2004) is not that "new'. Network analysis in geography is already known from Haggett & Chorley (1969) who have introduced topological measures of network structure. Barabási is a physicist who studies complex systems. Salingaros (2005b), a mathematician, has extended the approach to complex networks known as cities. The concept of network is linked to urbanism first by those urbanists who thought and designed cities in terms of basic infrastructure networks. Classical network thinkers such as the utopian Frank Lloyd Wright (see his 'Broadacre City') or practitioners like Soria y Mata and Cerdá (see Magrinyà, 2006 for details) have been unearthed by Dupuy (1991). The early networks include running water, sanitation, power, transport, and traditional telecommunications. As far as ICT is concerned , there is still a lot to be learned from the automobile system: from the automobile as a 'territorial adapter' (Dupuy, 2008b). It not only underlies today's urban mobility problem, but the transport network in general represent an important field of application for ICT, somehow easier to grasp than urban planning as such. The prospects for mobility will be dealt with later.

The network, in its modern meaning, is characterized by three principal criteria:

Topological criterion. The search of direct connections between points and the ideal of ubiquity characterizes the topology of a network.

Kinetic criterion. Instantaneousness, homogeneity of speed and the importance of rapid transportation and flows without time losses or interruptions; defines the movement or kinetic aspect of networks.

Adaptive criterion. The present-day meaning of the word network includes the notion of multiple choices with regard to connections, both in space and time. These connections may require a permanent support, a fixed infrastructure. On the other hand, ideally, the network has to be able to constantly adapt itself to new user requirements. (Dupuy, 2008a, pp. 19-20)

Dupuy, re-reading the classics, distinguishes three, interacting levels of network operators that (re) organize urban space. See *Figure 2.*

• Level one involves the suppliers of technical infrastructure networks. They are organized in sectors such as water, energy and transport. These have, traditionally, been public, monopolistic networks.

• On level two one finds the well known functional networks of common-interest users: production, distribution, consumption, and social contacts.

• It is on level three that the users of functional networks (in particular private households and business firms) actually make selective use of technical networks and their services for their specific purposes.

Now, when the networks have only just come to occupy a more recognized place in urban planning, everything is changing again: geographic scales are dilating to the edge of infinity; technology is developing at ever faster speed; and, with the liberalisation of network utilities, monopolies are giving away to almost uncontrollable competition. (Dupuy, 2005, p. 129) This gives rise to a 'splintering urbanism' (Graham & Marvin, 2001).

The question is whether the exposition of network levels also holds for the new ICT networks, Does it enable us, for example, to understand the virtual space of the Internet?, the most spectacular and challenging form of ICT in relation to urban planning?

The Internet, a network approach

The three, interacting levels of network operators are translated into Internet terms (for details of the following analysis see Drewe, 2002).

• Level one relates to the Internet infrastructure, for example, the ISP backbone, the layer of infrastructure closest to the users.

• Next, level two corresponds to the "Internet industry", e.g. the commercial domain.

• Finally, level three refers to the actual traffic on the Internet.

Analyzing the ISP backbone starts from counting nodes and links. The position of a given node (say, a city) depends, first, on the number of direct connections. The topological measures, developed by Haggett & Chorley (1969) can be used to measure connectivity. The importance of links, however, needs to be weighted for their capacity (bandwidth) as well as for multiple paths. Bandwidths is measured in terms of megabytes or gigabytes per second. Multiple paths depend on the proximity to an Internet exchange point. The more cooperating (peering) ISPs are associated with an exchanger point, the more paths are available to the users.

The "Internet industry" today is no longer limited to dot-coms. It includes all established companies that are using the Internet to improve their traditional activities and to develop new combinations of physical and virtual activities.

How do the data flow on the Internet between points of origin and points of destination? The question can be answered by applying a trace-route technique. Trace rotes show that the Internet functions smoothly in "good weather". But one may also encounter "bad weather" on a trip: information packets may get lost during the trip; delays may occur (they are measured in milliseconds); and information packets may get blocked past a certain network (hop) without reaching their destination.

The interactions between level one (Internet infrastructure), level two (Internet industry) and level three (traffic on the Internet) can be conceptualized (and measured) as interrelations between respectively supply, demand and performance as in *Figure 3*.

From this one could conclude that the Internet "behaves" like a conventional network – say, a transport network. It is a fact that the Internet infrastructure, too, is a physical one (the same holds, by the way, for the mobile-phone infrastructure). But it is the impact of the Internet on level three that is unprecedented: the Internet provides digital reach or action space to private households and business firms. The new action spaces represent "virtual cities" which tend to clash with municipal boundaries and with how urban planners usually perceive a desirable spatial (zonal) structure. In order to capture the new digital action spaces, one has to perceive cities as network cities. Reach or action space and the 'virtualization' of cities have already set in with the diffusion of the automobile as territorial adapter, but this has hardly been taken into account by transport and urban planning.

Emergent network-oriented urban planning

Both pioneering academic planners and practitioners have already provided us with examples of network-based urban form or network cities. It is the specific power of design to depict possible futures. Take for example the "integrated metropolis" (Roberts et al, 1999) or the "multiplex urban region" (Graham & Marvin, 2001). What these concepts have in common is that the shape of cities is moving towards a polycentric or multi-centered form which functions as a whole. Moreover, the concept of public space is extended, catering to physical as well as virtual interactions. This can be achieved through mutations of traditional buildings, integrating virtual elements (recombinant architecture, according to Mitchell, 1995) or new spaces built exclusively to provide access to virtual cities (gateways, as described by Firminio & Graham, 2001). These gateways include transformation spaces at street level; the multimedia kiosk with interactive services and information; and computers, shelves, desks, balconies, cables, digital and traditional all together (integrated activities, elements and spaces).

Historically in urban planning, the city center is supposed to take precedence over the urban periphery. The latter is seen as a somewhat illegitimate and residual part of the city. But high-density central areas and suburban sprawl *do* coexist. Hence maybe the real test of network-oriented, ICT-based urban planning is urban sprawl. Can sprawl be made 'smart"? The winning entry for the 'Millenium City" competition for Orange County, California tries to answer this question (Page, Philips & Siembab, 2003). The practitioners are proposing a network-oriented development comprising seven steps:

• development of a county-scale organization to stimulate the growth of e-commerce, e-business, e-government, distance education, and tele-medicine;

• creation of a county-wide high capacity Metropolitan Area Network (MAN) with commercial, non-profit, and government components;

• establishment of a system of Network Stations of different sizes at dozens of strategic locations throughout the county to provide access to the MAN (including high-speed access to the Internet):

• transformation of single-function buildings into mixed-function buildings with Network Stations adding functions;

• creation of plans for adding a mix of functions to single-function districts such that housing, jobs, and services will be integrated at distances not greater than two miles;

• creation of Neighborhood Transportation Zones around the Network Stations (mixed-vehicle streets catering to low-impact vehicles);

• beginning of reclamation of some land devoted to high-performance automobiles (such as housing construction on surface-parking lots in retail centers or office parks or reclamation of streets).

The principles of network-oriented development can be applied to new construction on greenfields or as in-fill and, maybe most important, it can help to retrofit sprawl to make it function as if it had been built following these principles right from the start. The underlying rationale of achieving a recovered urban pattern through transforming the existing pattern into a *networked* urban pattern can be illustrated by a network diagram shown in *Figure 4*. Note that ICT and transport networks are integrated.

As a certain follow up to the'Millenium City', the Hudson County Cyberdistrict proposal (WRT, 2003) includes three initiatives, the:

- Network Neighborhood initiative,

- Network Enterprise initiative,

- Cyber Strategy Coordination initiative. The first and second initiative comprise design elements. According to the Network Neighborhood initiative, ICT is used to increase the pull of existing activity centers to the immediately adjacent residents and businesses, reducing the demand for trips of over a mile or two. This initiative is also meant to a reinforce a sense of pride-of-place in the neighborhoods. The following pilot projects are included:

- Network Neighborhood Centers Plan with shared network access facilities or Network Stations (as in Orange County)

- Mixed use public facilities such as schools, libraries, public transportation stations, parks and city halls plus a Mixed Use Public Facilities Pilot Project focusing on rail platforms and stations

- Centers Plan Revision and Developer Recruitment (after the two pilot projects have been implemented)

- Neighborhood Transportation Zones, Vehicles and Services Pilot Project similar to the Millenium City) in the service areas for each designed center.

The Network Enterprise (or Electronic) initiative complements the Network Neighborhood initiative. The general idea is to facilitate the transition of delivery activities of each firm (from 'bricks and mortar' to digital networks) and to create demand for mixed function facilities. Several projects are envisaged:

- e-government targeting government services to citizens;

- countywide business incubator, using the new infrastructure of Network Stations;

- regional telework focusing on the administrative component of material handling and information companies;

- micro business web assistance, for example 'bricks and clicks' of retail stores;

- electronic meetings to cope with parking and congestion problems.

The proposed projects do not only affect the space-time budget of households but also those of companies with a pivotal role for ICT.

Page & Philips, who played an important part in both the Millenium City and the Hudson County Cyberdistrict, have pioneered with a design for Jersey City trying to integrate electronic space and electronic networks in urban planning (see Page & Philips, 2003 for

details). The Millenium City is also based on experience with The Blue Line Tele Village demonstration project of Siembab (1998).

Our examples of networked cities go beyond a hierarchical configuration of space and time in the city. They challenge the agenda of urban planners or urbanists, especially of those who still have the medieval pedestrian city on their mind.

What future for urban planning or, rather, what urban planning for the future?

Network-oriented

Traditional urban planning is still dominated by geometric notions that are expressed in a form language. This geometry is not a matter of space aesthetics, but rather related to real estate: zoning and density. However, with suburbanization city limits are shifting and densities fluctuate over space and time. A network approach is more apt to capture this reality. The examples of network-based urban planning testify to this. New design instruments are needed. Here are some promising avenues of research.

Dupuy (2008b) draws the attention to:

- the interface between networks and space (adhesion)

- preferential attachment (new nodes to an existing network preferably link to well-connected nodes; see also Barabási, 2002)

- the fractal approach, a better way of dealing with heterogeneous densities

- network time or a diachronic analysis of network evolution.

Salingaros (2003) has redefined the task of urban planners as one of connecting to the "fractal city", focusing on fundamental questions such as:

(i) what these fractal properties are; (ii) the intricate connectivity of the living urban fabric; (iii) methods of repairing urban space: (iv) an effective way to overlay pedestrian, automotive, and public transports; and (v) how to integrate physical connections with electronic connections. (Salingaros, 2003, p. 1) Page & Philips advocate design as an

interface, focusing on the relationships between reorganized forms of community, physical urban space, and ICT.

The search for new concepts and methods should include time, in particular urban time policies and the prospects for mobility (Drewe, 2004).

Finally (for the time being), Graham (2005) deals with strategies for networked cities emphasizing the remediation of urban place: a complex and subtle amalgam of new technologies and media fused on to, "remediating", old ones as Bolter & Grusin (1999) have put it – similar to Mitchell's recombinant architecture.

Let us take a closer look at two examples of avenues of future research, starting with design as interface. This has been illustrated by the project of revitalizing a distressed community in Philadelphia. Urban design, understood as interface, has been an alternative to physical redevelopment as the primary tool to revitalize the area in question, practiced over ten years to no avail. Three topics remain for further research:

- convergence of physical and digital flows and their nodes (as in the Hudson County Cyberdistrict proposal),

- interaction or participatory design to bring in users at an early stage of the design process'

- place, that is convergence and amplifying the way individuals perceive place (thus customizing non-place ICT).

Another example of a promising avenue of future research are urban time policies. They are already practiced in many Italian cities. Applied research on these policies is a specialty of LABSAT (Laboratory of Research and Design of Temporal Architecture Systems) at Milan Polytechnic. Keystone of design is the so-called chronotope: a physical time configuration (a) constructed historically; (b) inhabited permanently/ temporarily by a mix of changing populations; (c) breathes according to open/closed cycles of local functions both permanent and ephemeral; (d) is used by inhabitants according to phantasmagorical designs of timetables, calendars and present cycles; (e) is embedded into multi-scalar nets of person, goods and information mobility (Bonfiglioli, 2005).

The (new) urban rhythms have implications for the organization of transport. This has been take up by thepublic transport planners of Paris (Bailly & Heurgon, 2001).

Future mobility – in line with the evolution of urban rhythms and the use of ICT – requires new approaches to mobility research; innovations in mobility services which ask for concerted actions of different players; and new regulations.

Concepts and evaluation criteria, applied in today's urbanism and transport policy, must be rethought. *Density*, for example, can no longer be used as an indicator of potential exchange unless combined with accessibility (taking into account different speeds, from pedestrians to electrons, and different kinds of transport, i.e. passengers, goods and information). The *continuity* of the built environment, used to delimit politico-administrative boundaries, needs to be revisited as passengers travel beyond 30km/h. *Physical proximity* or *distance* becomes less important. As the growth of

distance covered by trips correlates with the growth of speed, access time becomes preferable to distance. A nearby place can be less accessible than a place far away. A final example is geographic *centrality* which within an agglomeration no longer guarantees accessibility. It can even be a handicap for private-car *users. New centralities emerge at nodes of interconnection and* multimodal platforms, polarizing various urban functions. As a consequence, the notion of inner city or city center changes. Notions more operational in future are *polarization, functional specialization* and *thematic concentration.*

Hence future mobility clearly tends to clash with conventional urban planning and design – once time is taken seriously in the ICT age.

ICT-based

The network approach is intertwined with ICT. But an ICT-based urban planning still meets with resistance from mainstream practitioners. Typical arguments pu**t** forward in defense of the status quo are: ”there is nothing new”; “it is not going to be dramatic”; “the institutions can handle it”; “ICT is only a tool”; it is all speculative and non-empirical”; “ it is uncontrollable and uncertain”.

These attitudes are not very promising in the face of ever new ICT developments in particular mobile media (Wilken, 2008). How does one explain the resistance amongst mainstream practitioners? Further, more recent research is needed (for earlier research see Fischer & Huning, 2000; Cohen, Van Geenhuizen & Nijkamp, 2001; Cohen, 2003).

At the end of the day, it all boils down to the unwillingness or incapability of organizing complexity. Urban planners should reread Jacobs (1992), first published in 1961 (!), in particular the last chapter on ‘the kind of problem a city is’.

While some underrate the role of ICT, others overrate it by postulating

“simplistic and technologically deterministic assumptions that ICTs will simply substitute for cities and urban life” (Graham, 2005).These assumptions also impede networked city strategies. Graham lists five major analytical and policy problems. Global urbanization and mobility trends are ignored. The same holds for the material bases of ICT. ICTs are overemphasized while place is underemphasized. Glossy ideologies of the information age camouflage neoliberalism and uneven development. And, finally, technical rationality is emphasized at the expense of politics. This leaves no room for social and policy innovation.

Hence if one is to take ICT seriously and deal with it professionally in urban planning, the best way to do so is to adopt a network approach, The model of interacting levels of network operators is less than simplistic and precludes technological determinism.

Conclusion

ICT is more than a visualization tool in urban planning. It also enables analysis and design (apart from on-line planning) – provided it is network-oriented. Emergent networked city strategies testify to this. There are also promising avenues of research.

Network-oriented, ICT-based urban planning is asked for in order to meet the challenge of sustainable cities. The vision of the connected city, contained in the New Charter of Athens, is three-dimensional, that is social, economic and environmental. It echoes the EU definition of sustainable development of urban space (European Commission, 1990). But will the urban planners accept the challenge? Network-oriented, ICT-based urban planning constitutes a paradigm challenge. This is a matter of reasserting the grounding power of the profession. Its future is at stake:

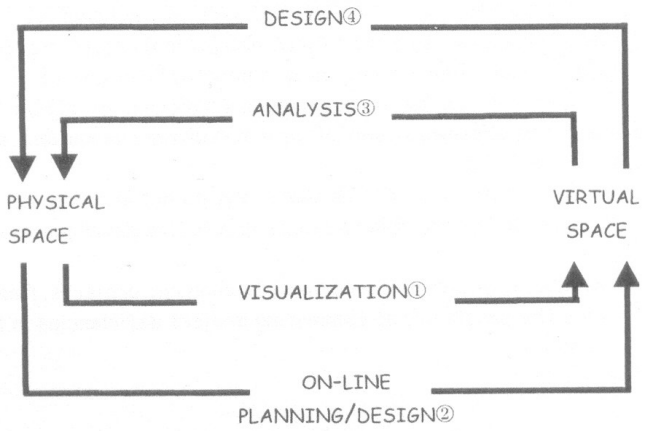
> The traditional art of physical design instead of reasserting its grounding power, is very much in danger of being relegated to a very insignificant role in the expanding, increasingly non-physical information space. (Droege, 1997, p. 6)

Or take, for example, Graham's warning:

> …the danger is that other groups who are more comfortable placing experimental place-ICT hybrids at the centre of their worlds – architects, artists, media professionals, and social movements – will totally dominate. This, inevitably, would lead to a further marginalization of urban planning, both as a discipline and a world of practice. (Graham, 2005, p. 109).

Figures

Figure 1.Interactions between physical space and virtual space



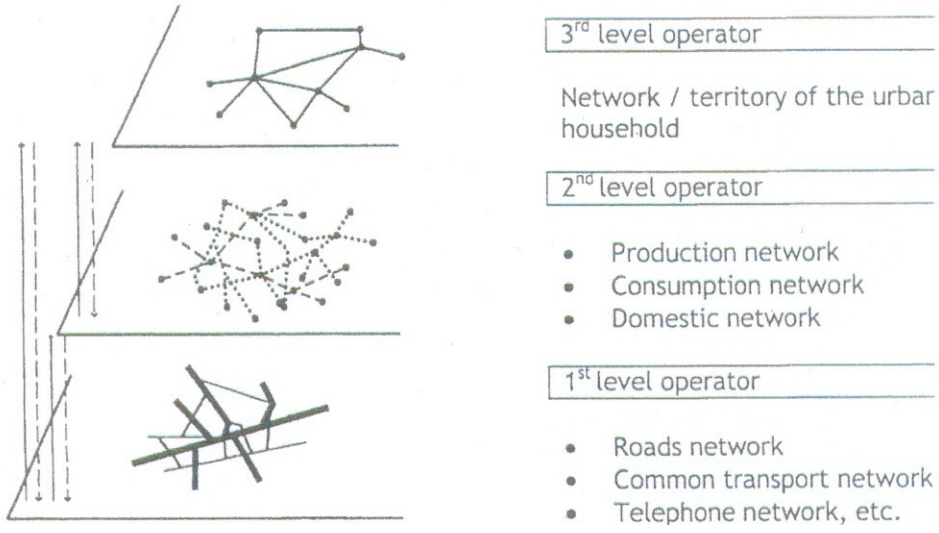


Figure2: The three levels of operators that (re) organize urban space (Dupuy, 1991: 119)

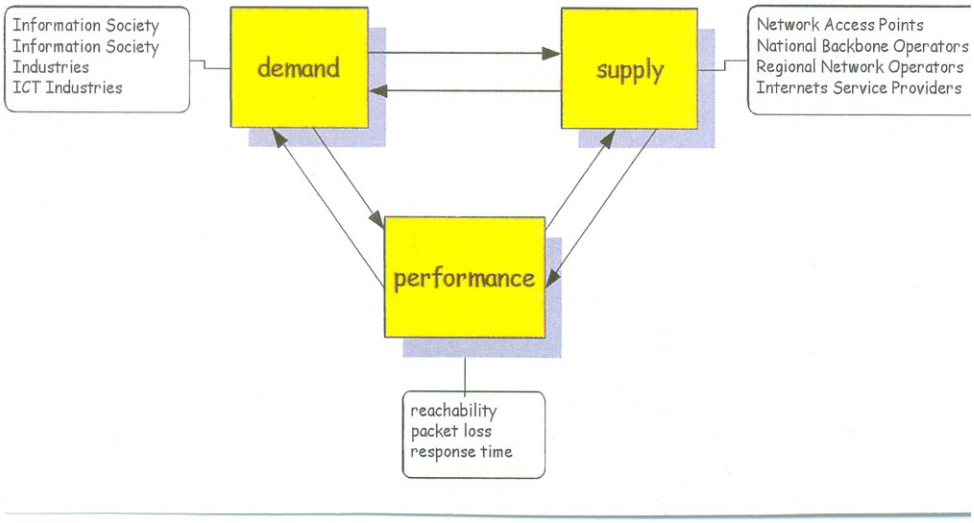
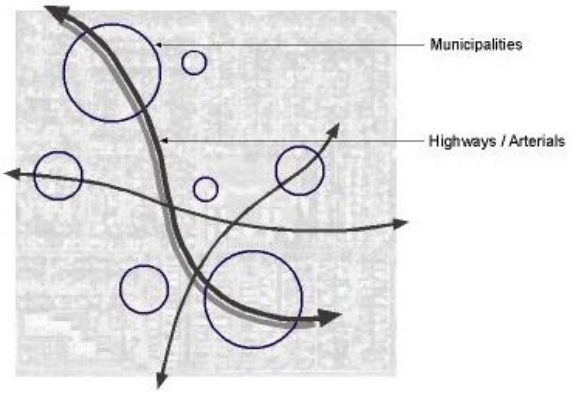
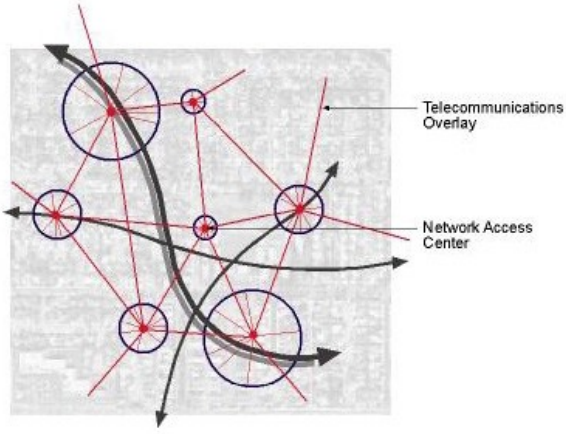


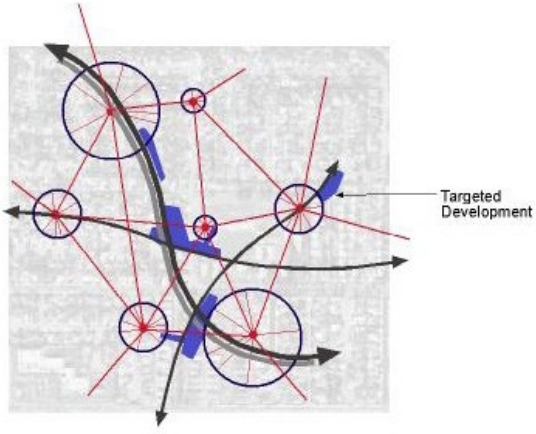
Figure 3. The Internet – Interrelations between supply, demand and performance



EXISTING URBAN PATTERN



NETWORKED URBAN PATTERN



RECOVERED URBAN PATTERN

Figure 4: The Millennium City Approach (original figures)

References

Bailly, J.-P. & Heurgon, E. (2001) *Nouveaux rythmes urbains et organizations des transports*, Centre National des Transports, Paris.

Barabási, A.-L. (2002). *Linked: the new science of networks*. Cambridge, MA: Perseus.

Bonfiglioli, S. (2005) *The city of time and the culture of* planning. Unpublished abstract. LABSAT, Politecnico di Milano.

Cohen, G. (2003) *Urban future and ICT policy: perception of urban decision makers.* Doctoral dissertation, Vrije Universiteit, Amsterdam.

Cohen, G., Van Geenhuizen, M. & Nijkamp, P. (2001) *Urban planning and Information and Communication Technology.* Tinbergen Insitute, Amsterdam.

Bolter, J. & Grusin, R. (1999). *Remediation: understanding new media*. Cambridge, MA: MIT Press.

Drewe, P. (2002). Understanding the virtual space of the Internet: a network approach. In M. Carmona & M. Schoonraad (Eds), *Globalization, urban form & governance* (pp. 135-142). Delft: DUP Science.

Drewe. P. (2004). *What about time in urban planning & design in the ICT age?* (Design Studio 'The Network City'). Delft University of Technology, Faculty of Architecture.

Droege, P. (1997). Tomorrow's metropolis: virtualization takes command. In P. Droege (Ed.) *Intelligent environments* (pp. 1-17). Amsterdam et al : Elsevier.

Dupuy, G. (1991). *L'urbanisme des réseaux: théories et méthodes*. Paris: Armand Colin.

Dupuy, G. (2005). Networks and urban planning: the evolution of a two-way relationship. In E.D,Hulsbergen, I.T. Klaasen & I. Kriens (Eds.) *Shifting sense: looking back to the future in spatial planning* (pp. 125-129). Amsterdam: Techne Press.

Dupuy, G. (2008a) From the magic circle to automobile dependence: measurement and political implications. In G. Dupuy, *Urban networks – network urbanism* (pp. 139-162). Amsterdam: Techne Press.

Dupuy, G. (2008b) The automobile system: a territorial adapter. In G. Dupuy, *Urban networks – network urbanism* (pp. 121-137). Amsterdam: Techne Press.

Dupuy, G. (2008c). A revised history of network urbanism. In G. Dupuy, *Urban networks – network urbanism* (pp. 19-38). Amsterdam: Techne Press.

Dupuy, G. (2008d). Progressive network urbanism: the way ahead for urban and physical planners. In G. Dupuy, *Urban networks – network urbanism* (pp. 243-261). Amsterdam: Techne Press.

European Commission (1990). *European Spatial Development Perspective*. Luxembourg: Office for Official Publications of the European Communities.

European Council of Town Planners (2003) *The New Charter of Athens 2003*. Firenze: Alinea Editrice.

Firminio, J.R. & Graham, S. (2001, September). *Typology for virtual cities: the interplay between physical and virtual urban spaces.* Paper presented at the Conference "EDA 2001 – European Digital Architect", Prague.

Fischer, B. & Huning, S. (2000) TeleCity vision: Konzepte administrativer Akteure im europäischen Vergleich.In M. Schenk (Ed.) *Beiträge zum 5. Symposium zur Rolle der Informationstechnologie in der und für die Raumordnung:* Vol. 1 (pp. 219-225). Wien: Technische Universität.

Graham, S. (1998). The end of geography or the explosion of space? Conceptualizing space, place and information technology. *Progress in Human Geography,* 22(2), 165-185.

Graham, S. (2005). Strategies for networked cities. In L. Albrechts & S. Mandelbaum (Eds.), *The network society: a new context for planning?* (pp. 95-109). London & New York: Routledge.

Graham, S. and Marvin, S. (2001). *Splintering urbanism: networked infrastructures, technological mobilities, and the urban condition.* London: Routledge.

Haggett, P. & Chorley, R. J. (1969). *Network analysis in geography.* London: Edward Arnold.

Jacobs, J, (1992). *The death and life of great American cities.* New ork: Vintage Books.

Magrinyà, F. (2006) The general theory of urbanization of Ildefons Cerdà: an urban network theory. In A. Graafland & L.J. Kavanaugh (Eds.) *Crossover: Architecture, Urbanism, Technology* (pp. 80-99). Rotterdam: 010 Publishers.

Page, S. & Phillips, B. (2003) Telecommunications and urban design, rerpresenting Jersey City, *City,* 7(1), 73-94.

Page, S. & Phillips, B. (2006) Urban interfaces: designing in-between. In A. Graafland & L. J. Kavanaugh (Eds.) *Crossover: Architecture, Urbanism, Technology* (pp. 60-74). Rotterdam: 010 Publishers.

Page, S., Phillips, B. & Siembab, W. (2003) The Millenium City: making sprawl smart through network-oriented development, *Journal of Urban* Technology 10(3), 63-84).

Mitchell, W. J. (1995). *The city bits:*

space, time and the Infobahn.

Cambridge, MA: MIT

Roberts, M. et al (1999). Place and space in the networked city: conceptualizing the integrated metropolis. *Journal of Urban Design,* 4(1), 51-67.

Salingaros, N. (2003, April). *Connecting the fractal city.* Paper presented at the Fifth Biennial of Towns and Town Planners in Europe, Barcelona.

Salingaros, N. (2005a). Complexity and urban coherence. In N. Salingaros, *Principles of urban structure* (pp. 85-114). Amsterdam: Techne Press.

Salingaros, N. (2005b) Theory of the urban web. In N. Salingaros, *Principles of urban structure* (pp. 17-38). Amsterdam: Techne Press.

Salingaros, N. & Coward, L. A. (2005). The information architecture of cities. In N. Salingaros, *Principles of urban structure* (pp. 172-188).

Siembab, W. (1998) Blue Line TeleVillage demonstration project. Retrieved from http://www.siembab.com

Watts, D.J. (2004). The "new' science of networks. *Annual Review of Sociology* (30), 243-270.

Wilken, R. (2008) Mobilizing place: mobile media, peripatetics, and the renegotiation of urban places, *Journal of Urban Technology*, 15 (3), 39-55.

WRT (Wallace Roberts & Todd LLC) (2003) *Hudson County Cyberdistrict, feasibility study,* Philadelphia.

Key Terms & Definitions

Network: A pattern of nodes and links characteristic of a wide array of phenomena: physical, informational, biological, social and so forth. It is the object of the multidisciplinary network science which, searching for common principles, algorithms and tolls, tries to unravel network behavior.

ICT: Stands for Information and Communication Technology. Originally it was called IT but with the rise of the Internet, emphasizing the role of communication, the C has been added. ICT comprises computer hardware, software and services.

Urban planning: An established public practice and organized profession. Its material object is physical space. It is about zone adapted to certain human activities (urban functions) and channels of communication connecting them and catering to transport. Urban planning combines land-use planning and transport planning. More or less synonymous terms are physical planning and urbanism.

Virtual: As in virtual space or virtual city: being functionally but not formally of its kind.

Fractal: "A rough or fragmented geometric shape that can be split into parts each of which is (at least approximately) a reduced-size copy of the whole" (Mandelbrot). The relevance to urban planning is illustrated by the fractal approach to network urbanism or by the fractal city.

Recombinant architecture: IC,

> decomposing traditional building
>
> types, produces mutants such as
>
> galleries/virtual museums, schoolhouses/virtual campuses, banking chambers/ATMs, department stores/ electronic shopping malls – and the like. A similar concept in the urban realm is remediation leading to place-ICT hybrids.

Mobility: The capacity or facility of moving people, goods and information.

Sustainable development: Urban spatial development that tries to balance three, often conflicting goals: social, environmental and economic.