

# Intelligent Cities

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## INTRODUCTION

In the dawn of the 21<sup>st</sup> century, information and communication technologies have radically altered the construction of our physical environment. Instead of constructing spaces that intermediate between nature and man's physical condition, a new orientation is emerging attempting to create spaces that increase man's intellectual capacity and improve the ways in which we use the environment in order to learn, innovate, and reach new frontiers. Intelligent cities belong to this new orientation; they are part of an ongoing research project for creating environments that improve our cognitive skills, our ability to learn and innovate, to foresee and prevent.

Intelligent cities combine two fundamental dimensions of our era: information technologies and innovation systems.

*... We use the term 'intelligent city' to characterize areas (communities, neighborhoods, districts, cities, regions) which have the ability to support learning, technological development, and innovation procedures on the one hand, with digital spaces and information processing, knowledge transfer and technology tools on the other hand. ... There are three basic components of an intelligent city: (1) the island of innovation formed by a community of people, production, exchange and other activities, (2) the virtual innovation system, which includes knowledge management tools and information technologies for online provision of information and innovation services, and (3) the connection between the physical and virtual innovation systems, in other words, the use of the latter by the island's community. (Komninos, 2002, p. 198, 201).*

To date, many territories have adopted "intelligent city" strategies. Public authorities in Singapore, Taipei (Taiwan), Spokane (U.S.), Seoul and Songdo (Korea), and Cyberjaya and Putrajaya (Malaysia) have implemented plans to make their cities more "intelligent." But, the most elaborated illustration of intelligent cities is to be found in the awards of the Intelligent Community Forum (ICF), which assesses communities, cities, and regions with respect to five criteria of innovation performance and digital government. During the last five years, about 20

territories from all over the world were selected by the ICF as top intelligent cities (<http://www.intelligentcommunity.org>).

## BACKGROUND

The concept of "intelligent city" is ambiguous. At least four different descriptions of what is an intelligent city (IC) can be found in the literature:

- ICs have been frequently defined as *virtual reconstructions* of cities, as virtual cities; the term has been used interchangeably as an equivalent of the "digital city" and "cyber city." Nonetheless, it is certain that communication capabilities offered by a digital platform or a virtual representation of a city do not suffice for an urban system to be characterized as "intelligent."
- A second approach is derived from various electronic and digital applications involved in the *management of city operations and functions*, which make very frequent use of terms such as "information city," "wired city," "telicity," "knowledge-based city," "virtual city," "electronic communities," "electronic spaces," "flexicity," "teletopia," "cyberville," etc., (Droege, 1997).
- Thirdly, ICs are conceived as environments with *embedded information and communication technologies* (ICTs) creating interactive spaces that bring computation into the physical world. From this point of view, intelligent cities (or intelligent spaces more generally) refer to physical environments in which information and communication technologies and sensor systems disappear as they become embedded into physical objects and into the surroundings in which we live, travel, and work. (Steventon & Wright, 2006). The "Intelligent Room" is a good miniature illustration of such environment; it is laboratory room which supports computer vision, speech recognition, and movement tracking, based on about fifty distinct intercommunication software agents that run on interconnected computers (Cohen 1997).

- Fourth, intelligent cities are conceived as territories that bring *innovation systems and ICTs* within the same locality, combining the creativity of talented individuals that make up the population of the city, institutions that enhance learning and innovation, and virtual innovation spaces facilitating innovation and knowledge management (Komninos 2002, ICF, op.cit).

This diversity in the understanding of intelligent cities is due to the multiple scientific and technology disciplines and social movements that take part in their creation, namely the movements towards “cybercities,” “smart communities,” “intelligent communities,” and “intelligent innovation environments.”

## CYBERSPACE AND CYBER CITIES

The term “cyberspace” was introduced by Gibson (1984) in his science fiction novel *Neuromancer* to describe a dystopian future based on virtual reality, artificial intelligence, and high-tech implants. With the explosion of the Internet, the meaning of the term changed radically and actually cyberspace came to describe an emerging universe of virtual spaces existing within the worldwide computer network, the Internet, and the World Wide Web. Cyber cities are virtual entities related to the physical and social environment of cities in two ways: first, by representing this environment with the help of maps, plans, two-and-three dimensional images, and text; and second, by managing this environment through the representation, communication and governance of functions and processes that take place within cities. This second aspect of cyber cities is more compatible with the origin of the term, which comes from “cybernetics,” a theory of communication and control which places emphasis on the functional relations between the different parts of a system, and in particular, the transfer of information, feedback mechanisms, and self-organization. Cyberspace and cyber cities have some unique spatial features which make them extremely valuable for managing the physical and social environment of cities: (a) physical distance is not valid and accessibility is just few “clicks” away depending on topological linkages only (Shiode, 1997); (b) cyber spaces can be easily modified; (c) digital representations are not limited by the characteristics of physical space; the production of digital space is extremely low-cost compared to physical space; and (d) digital communication enhances person-to-person communication and contact in local communities. Using these features, city planners may create digital constructs, which complement activities in the daily life of cities and facilitate the solution of urban problems.

## SMART COMMUNITIES

The initiative for smart communities was the first systematic effort to promote the link between cities and information and communication technologies. The World Foundation for Smart Communities launched it in 1997 in close cooperation with the California Institute at San Diego State University, which drafted the *Smart Communities Guide*. “A Smart Community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental, rather than incremental, ways” (<http://www.smartcommunities.org>). Put more plainly, a smart community is a community ranging in size from a neighborhood to a multi-county region in which public administration, enterprises and residents have understood the capabilities offered by IT and attempt to use those technologies to improve their everyday life and work in a significant, efficient manner. Smart communities in the U.S. and Canada are inspired to a large extent by global principles. Local development and prosperity depend less on decisions taken by the central-national government and more on initiatives and guidelines chosen by local leaders. Increased local responsibility is on the rise again in an age when information about markets and growth/development is becoming increasingly globalized. Globalization transfers responsibilities for decision-making at lower level, and smart communities offer some tools to deal with the new challenges (Eger, 1997).

## INTELLIGENT COMMUNITIES

Intelligent communities is a parallel, but more advanced effort. It is an initiative of the Intelligent Community Forum (ICF)/World Teleport Association seeking to promote the use of information and communication technologies for economic development, in large or small communities, in developed or developing countries.

*Intelligent Community is ICF’s term for what others have called the wired city, smart community, or e-city. It is the community—whether a town, city, county, or region—that views communications bandwidth as the new essential utility, as vital to economic growth and public welfare as clean water and dependable electricity.* (<http://www.intelligentcommunity.org>).

ICF’s major achievement is the annual “Intelligent Community” award. Each year the Forum selects seven communities from around the world, which excel in one or more criteria concerning information and communication technologies, knowledge and innovation. These criteria

are: broadband infrastructure, knowledge workforce, innovation, digital democracy, and marketing and attractiveness of the community.

## INTELLIGENT ENVIRONMENTS OF INNOVATION

Intelligent cities in North America and Canada stand on the convergence of two major trends of contemporary urban development: digital-electronic reconstruction of the city on the one hand, and the city as an environment for creativity and innovation on the other. The European effort to create intelligent cities is based on the same mix of digital technology and innovation capabilities, but it has a different departure from the U.S. approach. In Europe the starting point for intelligent cities and regions was the concern about territorial innovation systems. The central initiatives came from the Innovating Regions Network and the European Regional Development Fund supporting the convergence of innovation, digital technology, and sustainable development of regions. The connection between innovation systems and IT is evident in the actual orientation of EU regional policy towards (1) regional economies based on knowledge and technological innovation, (2) e-EuropeRegio: the information society at the service of regional development, and (3) regional identity and sustainable development (European Commission, 2000).

## FUTURE TRENDS

Intelligence has always been attributed to the individual, characterising outstanding human mental achievements. Human intelligence has a number of specific characteristics, such as perception, learning and memory, planning and feedback action, and communication. Researchers of human intelligence clearly link intelligence to innovation, insisting that intelligence is achieving something that has never been done before by the particular individual. Calvin (1998, p. 14, 18) considers,

*intelligence as the high-end scenery of neurophysiology -the outcome of many aspects of an individual's brain organisation which bears on doing something one has never done before ... intelligence is what you use when you don't know what to do. This captures the element of novelty, the coping and groping ability needed when there is no "right" answer, when business as usual isn't likely to suffice.*

In the field of artificial intelligence, the meaning of intelligence is based on a simulation with human intelli-

gence. Computer intelligence has been mainly defined with respect to the *Turing Test*, according to which intelligence exists when a human cannot distinguish whether a reply to a question has been given by a human or a machine. However, Fogel argues that a good definition of intelligence should apply to humans and machines equally well, and he defined intelligence as the "ability of a system to adapt its behaviour to the meet its goals in a range of environments" (Fogel, 1995, p. 24).

There are also social forms of intelligence: collective intelligence, swarm intelligence, intelligence of a population or a community. These forms of intelligence differ from individual intelligence.

*Collective intelligence ... is that which overcomes "groupthink" and individual cognitive bias in order to allow a relatively large number of people to cooperate in one process—leading to reliable action ... A less anthropomorphic conception is that a large number of cooperating entities can cooperate so closely as to become indistinguishable from a single organism with a single focus of attention and threshold of action.* ([http://en.wikipedia.org/wiki/Collective\\_intelligence](http://en.wikipedia.org/wiki/Collective_intelligence))

Collective intelligence is also important in the field of artificial intelligence. It is considered to be an emerging science, based on a largely distributed collection of interacting computational processes or multi-agent systems where (1) there is little to no centralised communication or control, and (2) there is a world utility function provided that rates possible histories of the full system (Wolpert & Tumer, 2001). Szuba (2001) proposed a formal model for collective intelligence, which assumes an unconscious, random, parallel and distributed computational process run by a social structure.

Intelligent cities will evolve towards a strong integration of all the above three dimensions of human, collective, and artificial intelligence. They will be constructed as multi-dimensional physical, technological, and social spaces of intelligence, learning, and innovation.

Their first dimension relates to people in the city: the intelligence, inventiveness, and creativity of the individuals who live and work in the city. This perspective was described by Florida (2002) as "creative city," gathering the values and desires of the "new creative class" made by knowledge and talented people, scientists, artists, entrepreneurs, venture capitalists, and other creative people, which have an enormous impact on determining how the workplace is organized, whether companies will prosper, whether cities thrive or wither.

The second dimension relates to the collective intelligence of a city's population. In a collection of definitions of collective intelligence by Atlee, the concepts of cooperation and synergy seem to come up constantly:

collective intelligence is defined as “the capacity of human communities to co-operate intellectually in creation, innovation and invention;” “the collective learning and creative process realised through exchanges of knowledge and intellectual creativity;” “the capability for a group to organise itself in order to decide upon its own future and control the means to attain it in complex contexts;” “the sharing of knowledge, know-how and experience in order to generate a higher individual and collective benefit than if they remained alone; the co-operation to solve more complex problems than individuals can;” “the capacity of families, groups, organisations, communities and entire societies to act intelligently as whole, living systems.” This is the institutional dimension of the city that creates wealth and prosperity through cooperation in knowledge and innovation.

The third dimension relates to artificial intelligence embedded into the physical environment of the city and available to the city’s population. This is a public AI, communication infrastructure, digital spaces, and public problem-solving tools available to the city’s population. It supports individual choices and assists communication, cooperation, learning, and innovation.

For us the concept of “intelligent city” and the plan to implement integrates all the three aforementioned dimensions of the physical, institutional, and digital spaces of a city. Consequently, speaking literally and not metaphorically, the term “intelligent city” describes a territory:

- With developed knowledge-intensive activities or clusters of such activities
- With embedded routines of social cooperation allowing knowledge and know-how to be acquired and adapted
- With a developed communication infrastructure, digital spaces, and knowledge/innovation management tools
- With a proven ability to innovate, manage and resolve problems that appear for the first time, since the capacity to innovate and to manage uncertainty are the critical factors for measuring its intelligence

What emerges from these conditions is a combination of individual, collective and artificial intelligence, which arises from people, cooperation, and IT infrastructure. It is the intelligence of the community and the intelligent machines at its disposal.

## **CONCLUSION**

An intelligent city is a multiplayer territorial innovation system. It combines knowledge-intensive activities,

institutions for cooperation and distributed problem solving, and digital communication infrastructure and tools to maximize this problem solving capability.

The basic level of an intelligent city is its population, especially knowledge workers in innovative companies and research and development (R&D) organizations. This level gathers the city’s knowledge-intensive activities in manufacturing and services, organised in a series of districts and clusters. Proximity in physical space is an important factor that facilitates the networking of enterprises, production units, service providers, and knowledge workers into innovative clusters, and into the wider urban innovation system.

A second level is made by institutional mechanisms for cooperation in learning and innovation. This level gathers institutions enhancing regional intelligence, benchmarking, venture capital financing, technology transfer, and collaborative new product development. These are intangible mechanisms necessary to mix individual capabilities and skills, and actualize the complex processes of innovation within the innovative clusters of the city.

A third level is made by information technology and communication infrastructures, digital tools and spaces for learning and innovation. These technologies create a virtual innovation environment, based on multimedia tools, network infrastructures, and interactive technologies, which facilitate market and technology intelligence, technology transfer, spin-off creation, collaborative new product development, and process innovation. A collection of such tools and multimedia which enable individuals and organisations to share knowledge and collaborate within virtual spaces, is presented at <http://www.urenio.org/virtual-innovation-environment.html>. However, the effectiveness of this virtual innovation environment is extremely limited if it is disconnected from creative organizations, communities, and clusters.

The endeavor of creating intelligent cities is still very much in its early days. The first applications are being developed with respect to innovative clusters and technology parks as intelligent clusters and intelligent technology parks. In such islands of innovation, the physical and institutional innovation system is being enriched with digital communication and knowledge management tools, creating an integrated physico-virtual innovation system. There are many indications that such spaces are going to multiply and cover most knowledge districts of cities. The incentive is strong, as the innovation capability of a cluster increases significantly within intelligent environments, offering information, skills, and virtual networks for cooperation.

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## KEY TERMS

**Artificial Intelligence (AI):** Systems which tend to simulate knowledge processes of the mind; a paradigm in which people attempt to elicit intelligence from machines.

**Collective Intelligence:** Knowledge capacity of human communities emerging from cooperation in creation, invention, and innovation.

**E-City:** A community or a group of buildings which follow the same IT architecture, infrastructure, and protocols.

**Intelligence:** Advanced mental abilities, including the ability to remember and use what one has learned, to solve problems, adapt to new situations, and understand and manipulate the environment.

**Swarm Intelligence:** Any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of insect colonies and other animal societies.

**Territorial Intelligence:** Part of a new family of concepts, such as business intelligence, territorial competitive intelligence, strategic economic intelligence, distributed intelligence, social or collective intelligence, emphasizing the organized and systemic collection, analysis, and dissemination of information for business and development purposes.

**Urban Complexity:** Interaction of many parts of an urban system giving rise to emerging properties that are not found in the constituting elements of the system.