

THE AGE OF INTELLIGENT CITIES

SMART ENVIRONMENTS AND
INNOVATION-FOR-ALL STRATEGIES

A nighttime photograph of a city skyline, likely Hong Kong, with numerous skyscrapers illuminated against a dark sky. The lights from the buildings are reflected in the water in the foreground.

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REGIONS AND CITIES

NICOS KOMNINOS

The Age of Intelligent Cities

This book concludes a trilogy that began with *Intelligent Cities: Innovation, Knowledge Systems and Digital Spaces* (Routledge, 2002) and *Intelligent Cities and Globalisation of Innovation Networks* (Routledge, 2008). Together, these books examine intelligent cities as environments of innovation and collaborative problem-solving. In this final book, the focus is on planning, strategy, and governance of intelligent cities.

Divided into three parts, each section elaborates on complementary aspects of intelligent city strategy and planning. Part I is about the drivers and architectures of the spatial intelligence of cities, whereas Part II turns to planning processes and discusses top-down and bottom-up planning for intelligent cities. Cities such as Amsterdam, Manchester, Stockholm, and Helsinki are examples of cities that have adopted bottom-up planning through the gradual implementation of successive initiatives for regeneration. On the other hand, Living PlanIT, Neapolis in Cyprus, and Saudi Arabia intelligent cities have started with the top-down approach, setting up urban operating systems and common central platforms. Part III focuses on intelligent city strategies: how cities should manage the drivers of spatial intelligence, create smart environments, mobilise communities, and offer new solutions to address city problems.

The main findings are related to a series of models which capture fundamental aspects of intelligent cities making and operation as environments enabling innovation-for-all. These models consider structure, function, planning, strategies toward intelligent environments, and a model of governance based on mobilisation of communities, knowledge architectures, and innovation cycles.

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Smart environments and
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Nicos Komninos

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To my family, Elena and Alex

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Introduction

The age of intelligent cities

For each age is a dream that is dying or one that is coming to birth.

– Arthur O’Shaughnessy

1. Intelligent cities for global challenges

Globalisation, urbanisation, and climate change have emerged as important challenges of the twenty-first century. The exponential growth of the urban population, which is expected to double within the next 40 years, is creating unprecedented socio-economic and environmental pressures. These are not, however, the only important trends that are shaping the new century. Debt crisis has become a permanent feature of the advanced economies of the EU and the USA; most dynamic growth regions are now to be found in China, India, and other developing Asian economies, and globalisation is channelling innovation investments into China and Southeast Asia. The narrative on the crisis that is gaining momentum defines its causes as lying in the production capabilities and low competitiveness of advanced economies, arguing that “advanced economies’ fundamental capacity to grow by making useful things has been declining for decades, a trend that was masked by debt-fuelled spending” (Rajan 2012). New countries are dynamically entering the world scene, and the G20 is replacing the G7 as the primary venue for economic co-operation. A new world is rising, challenging the established order and hegemony of the West; a global world not only fuelled by information technologies, intense competition, and global knowledge flows, but also shaped by local creativities and user-driven innovation.

A new generation of cities and a new city-planning paradigm are also emerging: knowledge-intensive, innovative, and intelligent cities, which are driving and being driven by the above global changes. The contribution of cities to the innovation-led global economy is tied into their power to create synergies between technologies, knowledge, and skills scattered across populations and organisations. Every resident of a city and every organisation located there – be it a business, research centre, or university – are agents of codified and tacit knowledge. Relationships of cooperation and competition shape how information and knowledge flow among them, how technologies are transferred and

2 Introduction

exchanged, and how synergies are forged. Digital spaces and smart environments are facilitating and strengthening such information and knowledge flows. On the ground of innovative agglomerations and digital spatialities, the 'Intelligent City' is becoming the dominant urban development and planning paradigm of the twenty-first century, connecting urban, innovation, and digital environments and setting in motion powerful socio-technological engines for change and sustainable growth.

Leaders and governments all over the world consider innovation systems and information technologies to be critical drivers for addressing the fight against poverty and the challenges of competitiveness, employment, sustainable environments, and development. A sea of Web-based applications and information networks are already available to strengthen the ability of cities and citizens to manage information, knowledge transmission, technology learning, and innovation. These include wired and wireless broadband networks, metropolitan-area networks, fibre-optic cables linking the various organisations of a city, websites and portals for city branding, virtual cities, social media for online communities, city guides, professional directories of businesses and organisations, local marketplaces, e-commerce applications, digital spaces for education and research, environmental monitoring and alert, digital representations of sites and districts, virtual tours of monuments and cultural heritage, applications for city management such as automated budgeting, automated property registers, integrated personnel management tools, automated social security applications, thematic databases and open datasets, e-government city clouds, applications for journey planning and way-finding, smart energy and water grids, sensors embedded into buildings, and many others. These infrastructures and applications advance the innovation potential of cities offering better communication, online spaces of collaboration, real-time information, and knowledge-management tools. An extremely rich digital spatiality over the cities has given birth to a family of new concepts, such as cyber cities, digital cities, smart cities, and intelligent cities, all placing emphasis on relationships of collaboration between citizens, innovation actors, and digital agents.

Within this landscape, *The Age of Intelligent Cities* describes new ways for dealing with city development, innovation, and smart infrastructure in cities and regions. It focuses on strategies for intelligent cities, the deployment of digital technologies mobilising communities and creating innovative solutions to problems of competitiveness, social cohesion, safety, energy saving, environmental sustainability, and governance. It is expected that intelligent cities will lead to more efficient cities and more competitive innovation ecosystems, enabling a global extension of collaboration networks and new solutions created by users and citizens. These two novel elements – global innovation networks and local user-driven innovation – become feasible within the digital spatiality of cities. Some good examples illustrating such *glocal* innovation ecosystems can be found in cities that have received awards from the Intelligent Community Forum, in the European Network of Living Labs (ENoLL), and the CONCERTO cities for energy and environmental efficiency.

The subtitle of the book *Smart Environments and Innovation-for-All Strategies* emphasises a key function of intelligent cities: the setting of smart environments that enhance collaboration within ecosystems of innovation, engaging innovators, enterprises, institutions, citizens, and end-users. Digital networking at local and global levels and large-scale data collection and processing, as well as smart environments, enable individualised strategies adapted to needs and aspirations of every city actor. Within smart city environments, citizens, companies, clusters, districts, utility organisations, and the public administration can find resources that allow them to organise their own ecosystems, discover know-how and partners for producing innovative products and services, and reach customers from around the world.

2. A trilogy on intelligent cities: twelve years of research

The Age of Intelligent Cities is the third book in a trilogy that started with *Intelligent Cities: Innovation, knowledge systems and digital spaces* (Routledge, 2002), followed by *Intelligent Cities and Globalisation of Innovation Networks* (Routledge, 2008). All three books describe intelligent cities as ecosystems of innovation and collaborative problem-solving enabled by digital spaces and smart environments.

The focus of the first book was the genesis of intelligent cities via evolutionary processes leading towards open innovation systems and physical-digital ecosystems, which took place during the last decades of the twentieth century. This evolution commenced with the formation of localised systems of innovation, such as clusters, industrial districts, and innovative agglomerations, where spatial proximity and inter-firm collaboration spread out knowledge spillovers and created trust and risk-sharing attitudes. Diversification and networking of these focal localities was the basis for the creation of larger regional systems of innovation and learning regions, where institutional settings enhanced innovation through joint projects, learning infrastructures, triple-helix alliances, innovation funding mechanisms, and targeted innovation policies. Then, in the third stage, local and regional systems of innovation came into contact with the digital world and the World Wide Web, giving birth to intelligent districts, cities, and regions. This meeting between innovation and digital systems that created environments of learning and innovation across real and virtual spaces was further strengthened by Web 2.0 platforms and participatory practices of user-driven innovation.

The second book moved from evolution to structure and examined the structuring of intelligent cities and the spatial expansion from isolated clusters to multi-cluster systems and networks with global dimensions. This expansion from local to global innovation systems was made possible by a three-layer structure composed of physical, institutional, and digital spaces. Knowledge and innovation networks at the local level acquire global dimensions through digital networking and virtual innovation environments, while institutions for innovation channel collaborations and partnerships locally and globally. Within such global, but also physical-digital, innovation systems, four fundamental knowledge functions emerge: collective intelligence, learning and technology acquisition,

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collaborative innovation, and global information dissemination and product promotion. Thus, the architecture of intelligent cities was defined by three spatial layers (physical, institutional, digital) and four knowledge functions (gathering of intelligence, technology learning, innovation, and information dissemination) emerging from collaborative networks across the three spatial layers. Based on this structure, intelligent cities were conceived of as innovation territories with developed knowledge-intensive activities, institutions, and routines for cooperation in knowledge creation and innovation, advanced broadband infrastructure, digital spaces and e-services, and a proven ability to innovate and resolve problems collaboratively.

Now, this, the third book in the trilogy, takes a step from structure to strategy. It focuses on the drivers of the spatial intelligence of cities, the fundamental processes that make cities intelligent, and new capabilities of distributed intelligence offered by recent technological developments. It looks at different terms used, such as 'cyber', 'digital', 'smart', and 'intelligent' cities, which denote different aspects of the same reality, and attempts to bridge the gap between intelligent and smart cities by pointing out the processes of city intelligence or city smartness. It also looks at the operational level of planning for intelligent cities and how planners can connect city challenges, intelligent city strategies, and implementation approaches by bottom-up and top-down procedures. It describes core strategies to be followed by clusters and city districts, individual companies, and city authorities wishing to sustain spatial intelligence and distributed problem-solving. As the subtitle suggests, this book is particularly concerned with smart environments that enable innovation strategies for all, offering opportunities to every person, company, and organisation of a city to become more intuitive and innovative by using digital technology, and by mobilising communities and collaboration networks.

3. Main ideas and contents of the third book

Intelligent cities and smart cities are now not only a core topic in the literature of urban planning and development, but are also of interest to many other fields of the social sciences, engineering, and management, dealing as they do with smart environments, energy optimisation, environmental protection, intelligent transportation systems, socio-technical systems engineering, innovation management, knowledge management, e-government, and so on. It is truly an interdisciplinary field, gathering know-how and expertise from the social sciences, city planning, engineering, information sciences. This subject area has emerged over the last 15 years and the number of publications has been increasing exponentially since 2009. As an interdisciplinary field, the subject is now taught in many different university departments and schools at MSc and PhD levels.

Quite simply, *The Age of Intelligent Cities* is an inquiry into the making of intelligent cities, the management of drivers of spatial intelligence, strategic planning processes, and strategies for all city actors. The vision is about the making of territories (districts, cities, other localities, regions) that prosper through human

skills, knowledge capabilities, collaborative innovation, information networks, and digital agendas; how this vision can be achieved; and which strategies can turn it into reality.

The book has a clear structure divided into three parts which elaborate on complementary aspects of intelligent city strategy, and especially how smart environments and digital city applications can be used to enable innovation by citizens, communities, stakeholders, companies, and public authorities. The core argument running through the chapters is that smart environments and online networks within intelligent cities enable a wide range of diversified and innovation-for-all strategies. In this sense, the book also contains a strong argument about innovation, describing a discrete stage in the evolution of the innovation paradigm, from linear to systemic, open, user-driven, and now 'innovation-for-all into smart environments'.

Part I is about the drivers and architectures of the spatial intelligence of cities. We start with the foundations, the building blocks of intelligent cities, and the pathways that infuse intelligence into innovation ecosystems. A fundamental question to start with concerns, What happens to an innovation ecosystem when it is placed into the context of the Internet and online communication networks? This is followed by other considerations: How do components, architecture, network geometry, hierarchy, and clustering within the ecosystem change? How do performance and resilience change? We know that cities are composed of smaller innovation ecosystems, and when these ecosystems start working in smart environments new capabilities emerge from the widening of collaboration, user-driven innovation, crowdsourcing, and real-time data streams. These enabling conditions offered by smart environments are primary fields and objects of strategy and planning.

Drivers of spatial intelligence can be found in different forms of distributed cognition which is organised across the physical, institutional, and digital space of cities. Such drivers include knowledge processes, large data sets capturing the working of urban systems, architectures of distributed know-how held by individuals, tools, learning environments, symbolic representations, digital assistants, and other components of distributed intelligence. The simplest form of such intelligence is representational intelligence (as the saying goes, a picture is worth a thousand words) offered by mirror-type digital cities. More-advanced forms of spatial intelligence that are discussed are 'orchestration intelligence', 'empowerment', and 'instrumentation intelligence' to be found in cities. Instrumentation intelligence becomes possible thanks to recent Internet technologies based on sensor networks and the Semantic Web, as a new form of collective intelligence captured by devices embedded into the physical space of cities. All forms of spatial intelligence are based on multi-level knowledge functions related to information collection, technology dissemination, and new knowledge creation that flourish within smart environments.

Part I starts with an overview of the literature on intelligent and smart cities in Chapter 1, a state-of-the-art account that sheds light on different concepts (cyber, digital, smart, intelligent) and different perspectives proposed by key authors and

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large information technology (IT) and consulting companies. It continues with three chapters focusing on different drivers of the spatial intelligence of cities, such as knowledge functions (Chapter 2),¹ smart systems and embedded spatial intelligence (Chapter 3), and alternative architectures of networking and operation (Chapter 4).²

In Part II, we turn to planning processes and discuss top-down and bottom-up planning for intelligent cities. As city authorities are becoming increasingly aware of the intelligent city–smart city paradigm, they are taking initiatives to more efficiently manage infrastructures and resources for addressing challenges of competitiveness, environmental sustainability, and social inclusion. In these endeavours, city managers and planners are more and more concerned with methodological and procedural issues: How to achieve city smartness? How can a city organise spatial intelligence? How can cities become more effective in solving urban problems? How can they make more with less, and increase competitiveness, sustainability, and inclusion?

Referring to cases from all over the world, we examine intelligent city formation processes and strategic planning steps: environment scanning, analysis, objectives setting, strategy design, implementation, launch and operation, monitoring, and assessment. Living PlanIT, Neapolis in Cyprus, Saudi Arabia intelligent cities, and other cities have started with a top-down approach, setting up urban operating systems that enable connecting devices (sensors, smart meters, QR codes, actuators), applications, and processes over a common central platform. On the other hand, metropolitan agglomerations and larger cities are adopting the intelligent city paradigm through the selection and gradual implementation of applications, with each one focusing on a specific problem of city growth, environment, transport, government, and so on. A series of case studies on smart city planning in Barcelona, Helsinki, Manchester, Oulu, and Thessaloniki are discussed to show how these efforts combine urban regeneration with the intelligent city planning paradigm.³

In terms of planning, the main challenge is to identify the best possible way of linking top-down and bottom-up initiatives; activating communities and stakeholders in defining distributed problem-solving strategies; and creating digital applications and solutions, operation models, and impact assessment methodologies. Our main contribution here is a planning roadmap for intelligent cities and districts, composed of three stages and seven steps. From the strategic planning perspective comes the division of the roadmap into three stages: analysis, strategy development, and implementation. From the standard model of intelligent cities come the three components of analysis, namely, the city, the innovation system, and the digital space. From smart environments come the components of implementation, such as software development, business models, and measurement. The roadmap starts by defining the problems that need to be addressed, then takes into account the physical, institutional, and digital structure of intelligent cities, and concludes with applications and solutions, business models for sustainability, and methods for measuring innovation and efficiency. It establishes a collaborative framework among the city's resources, its innovation institutions,

and its digital spaces, which generates solutions with the involvement of citizens, companies, and public authorities.

Part II starts with bottom-up planning experiences from different intelligent / smart city initiatives in Europe (Chapter 5),⁴ continues with top-down approaches in the Middle East (Chapter 6), and concludes with the planning roadmap connecting bottom-up and top-down perspectives (Chapter 7).

In Part III, having discussed the drivers of intelligence and planning processes, we focus on strategy: how cities can manage the drivers of spatial intelligence, formulate strategies, create smart environments, mobilise communities, and offer new solutions to city problems. The challenge here is diversity. Cities are agglomerations of ‘related varieties’, which feed innovation by bridging knowledge fields. Strategy and governance are examined from the perspective of diversity: how smart environments enable custom pathways and collaboration strategies for different city actors to be developed.

Initially, strategies are examined from the perspective of city districts and clusters comprising a city (Chapter 8). Each district (central business / financial district (CBD), historic centre, shopping centre and peripheral mall, industrial zone, technology district, university campus, port and airport district, recreation area, etc.) is treated differently because problems, functions, communities, and governance differ from one to the other. Within each and every district or cluster, problems and efforts for improvement are related to *innovation and competitiveness* of economic activities; *infrastructure and utility networks* for transport, energy, water, waste, and broadband; *quality of life*, well-being, social and digital divides, pollution, safety in public spaces, health and social care services; and *governance*, decision-making, democracy, administration services offered to citizens, and monitoring and measurement of performance.

We then look at strategies that are meaningful for individual companies (Chapter 9). Based on experiences and pilots from a number of research projects, we describe how companies can use smart environments to Build Their Own Innovation Ecosystem (BOWIE). BOWIEs are custom innovation ecosystems made by physical-virtual networks connecting actors along a value chain. They combine capabilities for market intelligence and discovery, technology development and use, and platform-based business models for collaboration and alliances. This is an extremely promising field, especially for smaller companies that enable them to take advantage of external knowledge and capabilities through digital collaboration.

From the perspective of city authorities, we discuss smart infrastructure, applications, and solutions that every intelligent city should have (Chapter 10). We also present a disruptive business model for intelligent cities based on open-source software, open data, and cloud technologies, which can offer enormous advantages to cities, breaking market and technology barriers by minimising smart city development costs and increasing the quality of e-services in terms of installation, update, instant scalability, trust, and reliability.

Part III – and the book – concludes with a chapter (Chapter 11) on governance of intelligent city ecosystems, in which we present a generic model of

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governance for actualising communities, defining architectures of knowledge, and undertaking activities for innovation based on cycles of user engagement. Overall, the book introduces readers to the fundamentals of intelligent city strategy, starting with strategy drivers, those factors and functions that generate spatial intelligence, going through strategic planning and operation, and concluding with strategies and disruptive business models that offer increased competitiveness and sustainability.

To date, intelligent cities offer an attractive prospect, a strategy and a vision for the future for sustaining islands of innovation in metropolitan agglomerations, rather than an urban pattern that has already been implemented. There is a long way to go before this planning vision is turned into urban reality. The intelligent city as an agglomeration of communities fully connected and instrumented, in which knowledge flows of learning, collective intelligence, and creativity enable all members to address their individual or communal problems and fulfil their aspirations remains a long-term vision.

Putting aside for the moment the intense wave of publication over recent years about intelligent and smart cities, especially after 2009, our knowledge of such innovative environments is still quite limited. The ability to create truly intelligent environments that open minds and empower citizens and producers to innovate is limited, as well. This is a weakness both in terms of understanding the complexity of intelligent environments and in terms of strategic planning and management of the drivers of spatial intelligence. This challenge is guiding the present book, and the aim of the 11 chapters is to enlighten fundamental aspects of intelligent cities by describing five interrelated models of their making and operation: (1) a model of structure, (2) a model of spatial intelligence, (3) a model of function, (4) a model of strategic planning, and (5) a model of governance.

Notes

- 1 An earlier version of Chapter 2 was published in Komninos, N. (2009). Intelligent cities: Towards interactive and global innovation environments. *International Journal of Innovation and Regional Development*, Vol. 1, No. 4, 337–355. Permission granted by Inderscience, which retains copyright of the original paper.
- 2 Chapter 4 is based on two previous publications: Komninos, N. (2011). Intelligent cities: Variable geometries of spatial intelligence. *Journal of Intelligent Buildings International*, Vol. 3, No. 3, 172–188; and Komninos, N. (2013). What makes cities intelligent? In M. Deakin (ed.) *Smart Cities: Governing, modelling and analysing the transition* (pp. 77–95). London and New York: Routledge. Permission granted by Taylor & Francis.
- 3 These case studies were published in the special issue: Komninos, N. and Schaffers, H. (eds) (2013). Smart cities and the Future Internet in Europe. *Journal of the Knowledge Economy*, Vol. 4, No. 2, 119–134.
- 4 Another version of this chapter was published as Komninos, N. and Tsarchopoulos, P. (2013). Towards intelligent Thessaloniki: From agglomeration of apps to smart districts. *Journal of the Knowledge Economy*, Vol. 4, No. 2, 149–168. Permission granted by Springer.

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