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## Building human-centered systems in the network society

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### Abstract

This paper considers the development of selected projects which have been engaged in building information and communication networks in urban and regional environments, with the ultimate goal of developing networked places. It is argued that such networks have the potential to attract and mobilize people into a “culture of knowledge” and make public administration and free markets more effective, but require adequate infrastructures, incentives and institutional frameworks.

The analysis builds on the co-evolution of human and social contexts at local levels and the endogenous process of technical change, namely in terms of information and communication technologies. We conclude that networked places should be designed holistically, adaptable to change and continuously assessed in order to accommodate humanity.

The first generation digital cities have shown the need to build flexible and interoperable technological infrastructures, yet robust and user friendly, to support knowledge networks. The new paradigm of semantic grids may respond to the increasing complexity and heterogeneity of humanity and urban environments and support more effectively the creation and diffusion of knowledge networks to help mobilizing the information society and to promote the inclusive development of networked places.

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## 1. Introduction

Within the current socio-economic paradigm, in which engineering systems are key for the sustainable development [1], the region is considered the place of *untraded interdependencies*, meaning “...conventions, informal rules, and habitats that coordinate economic actors under conditions of uncertainty. These assets are a central form of scarcity in contemporary capitalism, and hence a central form of geographical differentiation” [2] and the basis of economic growth. The actors include “firms, organizations and institutions [that] interact in the generation, diffusion and use of new—and economically useful—knowledge in the production process” [3]. Some of these interactions are based on information and communication technologies, ICTs, in terms of digitally enabled knowledge networks.

In fact, Internet and other media were initially believed to neutralize the centripetal forces of metropolization, maybe even to start a global process of deurbanization [4], but (as a matter of fact) physical proximity is playing a critical role on technical change and economic development [5]. As a consequence, local systems of innovation are increasingly important in the global society [6] and cities do provide energized places for contacts, ideas and creativity where tacit and explicit knowledge can be exchanged effectively through face-to-face communication. Opportunities for knowledge spillovers through social interaction are increasingly provided in urban environments, facilitating learning and increasing social capital [7].

Although we are still in a very early and limited stage of what Mitchell [8] called “cities of bits”, it is clear that it has become a “commonplace” to discuss the diffusion of knowledge, and the “knowledge-driven economy” in general, in close association with the introduction and use of information and communication technologies [9]. Following recent analysis for US regions, ICTs are “both in and of themselves the products of innovation, as well as critical tools that create interfaces, linkage and knowledge networks between the main players in an innovation system” [10]. ICTs are, nonetheless, embedded in a human context that calls for the design of human-centred systems, in terms of recognizing the importance of social and cultural shaping forces, while developing and exploiting technological systems [11].

In this context, what challenges are facing the diffusion and adoption of ICTs at regional level? And what types of engineering systems may contribute for the mobilization of the information society? These questions have motivated the work behind the present paper, which has considered the development of case studies in selected cities and regions engaged in building digital networks.

In previous papers we have reviewed the development of Portuguese digital cities and argued that knowledge networks have the potential to attract and mobilize people in the information society and make public administration and free markets more effective. In addition, we have argued that knowledge networks promote learning trajectories for the inclusive development of society. Nonetheless, they require effective infrastructures, incentives and adequate institutional frameworks [12]. Market mechanisms do not necessarily work at the level of the issues associated with digital cities, foremost in less developed economic zones. Effective mixes of public support mechanisms are required. As the successful implementation of knowledge networks requires a long-term perspective, digital cities cannot be promoted independently of a policy fostering infrastructure capacity and connectivity [13,14]. The analysis builds on the need to continuously adapt to regional trajectories, both social and technological, and to foster learning opportunities for increasingly diversified local communities. In sum, digitization should enhance social capital as a relational infrastructure for collective action [15], and creation and diffusion of knowledge.

This paper attempts to frame these aspects from the perspective of human-centred technical systems. We begin by examining some aspects of the mobilization of the information society and ICT adoption and diffusion at a regional level. Then we will continue by discussing the social and cultural shaping of information technologies. Finally, we conclude by briefly presenting a summary of our most important conclusions in terms of necessary social and technological conditions for the establishment of knowledge networks.

## **2. Mobilizing the information society through digital cities**

For the first time in human history, the urban population is matching the rural population. While in 1950, 29.76% of the world population lived in urban areas, this value rose noticeably to 37.95% in 1975, 47.28% in 2000, and is expected to reach 60.22% in 2030. The total urban population will actually grow more than six-fold from 0.74 billion in 1950 to 4.98 billion in 2030, when about four fifths of city dwellers will reside in less developed regions. In fact, most of the expected world population increase from 2000 to 2030, which is expected to amount to 2.21 billion new inhabitants, will be concentrated in urban areas, namely on less developed regions, where it will exceed 2 billion new residents. For the same period (2000–2030), the average annual growth rate of 1.85% for population in urban areas will almost double the annual rate for the total population of the world (1.04%). Furthermore, ten (10) megacities, exceeding 10 million inhabitants each, can be found in the world today, with seventeen megacities estimated to be in place by 2030 [16].

The image of the city has evolved accordingly, from socially coherent and spatially circumscribed entities to complex juxtaposition of boundless urban processes [17]. In his seminal book, Peter Hall renders some theoretical visions of the urban phenomenon starting with the influential ideas of Ebenezer Howard (Garden Cities) and Patrick Guedes (Industrial City) at the turn of the nineteenth century and developing contemporary views, including: Corbusier's cities of towers; autonomous communities; automobile suburbs; institutionalized land-use planning and the idea of the city as a machine of wealth creation [18]. But at the end of the twentieth century, a new paradigm has emerged with Castells' "Informational City" [19]. As pointed out by Susser [20], "the restructuring of capitalism involved, first the concentration of knowledge as the source of profit and, secondly, the export of production to increase profitability", requiring "a flexible organization of manufacturing and greatly increased subcontracting, so that, as a consequence, horizontal, loosely connected networks directed by elite experts at the centre replaced the vertical integration of the industrial era".

While these aforementioned theoretical visions may vary they share a common understanding that cities are characterized by dense and heterogeneous singularities of people and buildings in a specific place, or as proposed by Spiro Kostof [21], "cities are places where a certain energized crowding of people takes place". And he adds that a city has "nothing to do with absolute size or absolute numbers: it has to do with settlement density". This density, among other possibilities, increases the opportunities for social networking [22], one of the main enablers of localized innovation and entrepreneurship. As pointed out by Zook [23], "despite the space transcending ability of Internet technology, [...] the commercial Internet clustered in a few regions within the United States during the period from 1994 to 2000. The existence of these agglomerations runs counter to expectations that the Internet would bring the "end of geography".

The convergence of fresh interpretations of the urban processes and the new promises of ICTs, particularly those related with virtual communities and virtual reality, created the necessary background for the development of a new image of the contemporary city: the “digital city”. This original concept proposes “to build an arena in which people in regional communities can interact and share knowledge, experiences, and mutual interests. Digital cities integrate urban information (both achievable and real time) and create public spaces on the Internet for people living/visiting the cities” [24].

There are several other interpretations of digital cities, from local Internet directories to electronic government portals [25]. Perhaps, these diverse interpretations reflect the relative infancy of the digital city concept. Innovations are often “fuzzy” at the beginning, and it takes a while before they establish their own evolutionary paths from pre-existing ones or simply fade-out with time. Maybe instead, these varied readings about digital cities simply mirror the different views about real cities and they will still coexist for a long time. We will use for the purposes of this paper the concept of digital city as a new layer of urban networked infrastructure, based on telecommunications and networked computers, to support and augment urban everyday life.

The first known “digital city” was based on Amsterdam’s well studied community network experiment in 1994 (DDS—De Digitale Stad), based on the FreeNets and Community Networks in the USA and in Canada [26,27]. Another very well known early experience was based in the “Kyoto Digital City” project, as launched by NTT and Kyoto University in 1998 aiming to “create next-generation systems for digital communities and to explore basic research issues” [28]. The Amsterdam and Kyoto digital city projects have influenced, over the last decade, many city developments and guide “digital city” projects throughout the world.

A typical example of this process has been the experiences in Portugal with digital cities, which started in 1998 through a program jointly funded by the Portuguese Government and the European Union and led by local governments. Private investments were insignificant.

The program involved 7 separate projects that included the funding of digital cities in 5 small and mid-sized cities (*Aveiro, Bragança, Guarda, Marinha Grande, Castelo Branco*) and in 2 rural regions (*Trás-os-montes* and *Alentejo*). The aims of the program were to (a) improve the quality of life in cities; (b) contribute to development of peripheral areas; (c) improve local economy and employment; and (d) close the digital divide [29].

In terms of regional penetration, the 7 projects covered about 11.30% of the total Portuguese population and about 42% of the total surface of Portugal. All projects involved a broad range of relevant actors and change agents within each one of the territories. All projects were led by local municipalities. However, only three projects incorporated the participation of local higher education institutions (*Aveiro University, Polytechnic Institute of Bragança, Trás-os-Montes University*).

For the seven projects the institutional framework established by the Portuguese government was both flexible and promoted local voluntary initiatives. The key digital city guidelines were (a) the provision of information or services related to local public administration, (b) the provision of information or services with social implications (e.g., healthcare), economic impact (e.g. business-driven corporate networks for regional competitiveness), and (c) the promotion of local cultural contents [30].

A weakness at the project level was that specific initiatives to mobilize and promote the adoption of the Information Society were not capitalized upon, at least beyond that given to the supply of infrastructures, content and applications [14].

Since 2001, the Digital Cities program was significantly expanded in terms of incentives, territorial coverage, and content. It is still jointly funded by the Portuguese Government and the European Union,

with private investment practically non-existent. However, the former flexibility of institutional framework guidelines established by the Portuguese government have grown more strict in terms of content mix and digital city typology with limitations on local voluntary initiatives.

The current program involves 5 cities and 21 regions focusing basically on four areas: (a) production and distribution of local digital content (tourism, daily life, business opportunities, job offers, blogs, etc.); (b) local e-government, including both process reengineering and provisioning of advanced services through the Internet; (c) infrastructures (data centers and closed municipal networks); and (d) mobilization initiatives like public access areas, both wired and unwired, and mobile road shows [31].

Globally, the expanded program covers two thirds of the Portuguese population and about 80% of the national territory. Again, the projects involved a broad range of relevant actors, being, this time, mostly led by the recently created regional development agencies or municipal associations. Local higher education institutions (universities and polytechnic institutes) were much more involved both in the design and implementation of the projects.

### 2.1. *The case of the Aveiro Digital City*

Aveiro Digital City project represents an interesting case study in so far as it is promoted and coordinated by an autonomous organization formed by the municipal association, local governments, the local university and the incumbent telecommunication operator, Portugal Telecom. Aveiro Digital City represents the result of a long preparation effort and it provided the opportunity to evaluate concepts and then to roll-out a much more comprehensive initiative.

*Aveiro* is a seaport in the north of Portugal, located at the Vouga estuary, with a population of approximately 65,000. The city's innovative and active character, although recent, draws from the singular institutional framework established in close collaboration between the local university (*Aveiro University*) and the local business community, mainly driven by Portugal Telecom.

Following the launch of the first phase of public funding program in Portugal (1998–2000), the municipality, the university and the incumbent operator set up a public–private partnership to develop the idea of Aveiro Digital City focusing on (a) quality of life in the city; (b) democratic participation; (c) extensive access to public and private digital information and services; (d) local public administration modernization; (e) inclusive development and sustainable growth; and (f) job creation and lifelong learning [32–34]. The complete funding life cycle was expected to be 8 years, with the first phase of the project from February 1998 to December 2000, totalling an investment of 5,590,000 Euros.

The second phase, originally planned to start in January 2001, has only begun on June 2003 and is planned to last until December 2006. The new round of public funding reaches 20 MEuros and expands the territorial coverage to 10 other municipalities (*Ovar, Estarreja, Albergaria-a-velha, Sever do Vouga, Murto, Águeda, Ílhavo, Oliveira do Bairro, Vagos and Mira*), totalling about 350,000 inhabitants.

Both phases had a troubling start—budget allocation negotiations and bureaucracy caused lengthy delays, mostly for over than one year, in the formal approval procedures and the technical implementation schedule—the first phase included 37 projects covering several different aspects of the use of information and communication technologies. Emphasis was given to infrastructures and digital contents, including local e-government, e-health, e-business and entertainment.

E-business and education related activities accounted for 35.1% of the total number of approved projects and 40.7% of the budget allocated. E-government used up to 20.4% of the available funds. University-based and e-health projects included only two projects and utilized less than 9% of the total

budget. On the other hand, entertainment, culture and arts accounted for about 30% of the total number of approved projects, but only received about 8% of the total budget available. In general, ICT infrastructure—computers, applications, Internet access and basic ICT training—was the most important component of all projects, while investments in activities oriented towards the mobilization of the population for the information society were practically inexistent. Consequently, the evaluation of many activities claims for reduced levels of public participation, with some of the initiatives falling short from their original objectives [34]. E-government and other projects involving basic and secondary schools had more permanent effects, while e-commerce and e-health performed poorly. Budget cuts and uneven financing flows during the implementation phase posed extra difficulties and increased risk unnecessarily.

The second phase includes 77 projects with emphasis on training, public Internet access areas, mobilization, local e-government, education, e-health, social services, regional competitiveness, tourism, culture and daily life. By the end of 2005, Aveiro Digital has already certified 10,487 people in basic computer skills. The expected number of certifications will exceed 45,000, or more than 13% of the population. Furthermore, 91 Internet public spaces were installed, including one for every parish of all participating municipalities. During 2005, 68,007 users, about half of them between 10 and 18 years old, expend 234,877h navigating on the Internet [35].

The time frame of the project and the extent to which public funds were continuously available at the early stage appear to be critical conditions, namely to guarantee the evolution of a process of gradual competence building. This is a major issue learnt from the Aveiro project and here we refer to competence as skills and capacities, both individual and collective. It is important to stress that new skills are part of the competence foundation, but we are not necessarily arguing that technological change is skill-biased. When we consider competence, we focus on generic skills, including higher levels of education (who can ever be against more education?) but also capacities that are more generic, such as creativity, risk-taking, and initiative [14].

### **3. Discussion: the social and cultural shaping of ICTs**

Our discussion will focus on the analysis of the cultural and social shaping of information and communication technologies and we will argue for the need to consider human-centred infrastructures and systems. Although incentives and infrastructure greatly inform our understanding of economic development, they do not tell the whole story about the differences across the various projects discussed above. This is because both incentives and infrastructure do not operate in a vacuum, shaping and being shaped by the particular context where they operate. In the scope of our analysis, the city or region must have embedded a set of social capabilities that define the context under which digital cities evolve. Consideration of contextual issues in building-up network societies has not always been considered in many different situation throughout the world, as acknowledged by Castells [5], among others, and evidence shows that specific measures to promote adequate contexts and mobilize people in the projects considered in this paper have also been scarce.

Following the seminal work of Mansell and Steinmuller [9], the mobilization of the information society must overcome some critical uncertainties: (a) unclear expectations related to the level of dematerialization of social and economic activities; (b) effective adoption patterns of new technologies by citizens and customers, particularly influenced by accessibility, affordability and usability; and (c)

unpredictability of demand for interactive services from both localized and geographically dispersed communities. Our evidence supports the critical need for adequately managing these aforementioned uncertainties and shows the necessity of effective infrastructures, incentives and adequate institutional frameworks to be promoted over time and across space.

But the implementation of complex technology-enabled infrastructures typical of digital cities calls for a broader approach where social and cultural aspects are integrated in early design phases to mitigate uncertainties, such as sustainability, flexibility and scalability. Moreover, we can expect that digital cities to have other unexpected properties, or emergent properties, “developed by users of a system” and “often unbeknown to the system designer” [36]. Being so, the stakeholders involved in the co-evolution of urban areas and ICTs would be better off if, as proposed by Cooley, “the current mechanistic paradigm of technological and societal development [would be substituted by] human-centered systems [that would] provide a powerful alternative philosophy for system design and a broader educational and societal development”. He adds that “[this philosophy] regards the social and cultural shaping of technology as central to the design and development of future technological systems and society as a whole”, in terms of “knowledge-based adaptive human-centred environments” [37].

Expanding this conceptual framework to the entire city or even whole regions in order to consider the way millions of people interact with information and communication technologies in their daily life, it is clear that the initial approach to designing digital cities described in Section 2 should be reconsidered. Table 1 describes main implications and requirements of emerging trends in the mobilization of information society, so that the vast majority of potential late adopters are inclusively considered in future digital city projects. As Dertouzos [38] argues, we can avoid “drowning in information overload and computer complexity only by throwing out last century’s model for computing and adopting—indeed, demanding—a new computing philosophy, a new master plan, that lets people interact naturally, easily, and purposefully with each other and the surrounding physical world”. And he adds, “to put it in action requires three big steps: changing the mind-set of users and designers; ensuring

Table 1  
Emerging trends in the mobilization of the information society, towards a new generation of “Digital Cities”

Layer of analysis	From	To	Implications and requirements
Infrastructure/access	Conspicuous objects	Invisible infrastructure	Embedding ICT infrastructures in urban daily life, fostering human-centered systems
	Fixed access	Roaming	Competitive mobile services and improved regulatory framework for increased individual participation
Content/services	One-way distribution of information	On-line collaboration and participation	Specific knowledge of institutional and local contexts in order to help developing interactive contents
	Web functionalities	Networked Activities	New competences in content and services development, enhancing user activities and networks
Human and social Context	Technology supply	Mobilization of users	Mobilizing “change agents” to foster communities of practice, CoP’s, and user involvement
	Standards	Interoperability	Building individual and social competences through knowledge-based adaptive human centred environments

that our machines are easier to use and make us more productive; and insisting that new technology reach many more people”.

Norman [39] noticed that, in fact, technological systems tend to increase internal complexities exponentially to meet the continuous evolution of users needs, but its interfaces are likely to be constantly simplified to perform specific activities to a broader base of users. The opportunities and possibilities of the co-evolution of urban development and ICTs are so vast that this strategy, “edge to core”, would be more appropriated to implement the next generation of digital cities. It starts by finding out the critical interfaces between city dwellers and its supporting ICT infrastructure and only then developing objective technology-enabled services to meet existing or potential demand.

On the other hand, the number of potentially connected nodes within urban environments has significantly increased in the last couple of years and includes GSM/GPRS wired PDAs, Wi-Fi enabled laptops, 3G mobile phones, ADSL connected game consoles and entertainment PCs, Bluetooth tablet PCs, Videophones, Interactive TVs, real-time environment sensors (e.g. air and water quality), large databases (corporations, libraries, museums, public administration), GPS oriented cars, and GPS traceable trucks and buses. On the other hand, new layers of territory-related data and information are being created in a daily basis, like municipal geographic information, Internet city guides, interactive maps and routes, and 3D worlds. To cope with this increased complexity, a new technology must add another layer of distributed computing and data management to the current Web based information distribution paradigm. In fact, as computers and networks become ubiquitous and interlinked, they will turn out to be another invisible urban infrastructure, like electric grids and sewage systems that will sustain daily life.

Grid computing, as described by Berman et al. [40], can be the “computing and data management and infrastructure that will provide the electronic underpinning for a global society in business, government, research, science and entertainment. Grids, integrate networking, communication, computation and information to provide a virtual platform for computational and data management in the same way the Internet integrates resources to form a virtual platform for information. [They] are intrinsically distributed, heterogeneous and dynamic”. Grid computing was shaped by the same early driver that has pushed the scientific communities of practice to build the Internet and the World Wide Web: the construction of a virtual collaborative environment for scientific research. The main objective still is, as it was before, to share networked resources for creation, accumulation and diffusion of knowledge.

Probably, on top of the current 4-layered grid architecture—hardware resources; interoperable protocols; common grid middleware; and grid applications—an activity-based, human-centred layer of services should be added to help the mobilization process. This territory-related additional layer could be enabled by specific knowledge-driven ontology [41], natural language [42] and/or the semantic web capabilities for “handling and support for knowledge processing” [43].

#### **4. Conclusions**

The co-evolution of urban environments and information and communication technologies was analysed in terms of the social and cultural shaping of information technologies and related uncertainties for their application to regional and urban contexts. This analysis was based on observations in different Portuguese digital cities and regions with the ultimate goal of increasing regional competitiveness, by promoting public awareness and participation in decision-making processes. It is argued that the territory

is a basic infrastructure that justifies and invites for the construction of several layers of information, but above all for communication infrastructures and digital contents well arranged with local contexts.

The analysis led us to suggest that while the role of public policies needs to be re-examined, the cultural and social shaping of information technologies requires the specific development of human-centered systems to support community building activities. We refer to “edge to core” strategies for the next generation of digital cities.

The reflections were based on the need to consider uncertainty in the mobilization of ICTs, which requires individuals, firms and organizations to operate in dynamic environments, where markets and technology are changing fast and in unpredictable ways. This calls for the need to combine flexible infrastructures and adequate incentives with institutions, to foster the necessary context for digital cities to succeed. The new paradigm of semantic grids can help ICT complexity to be alleviated and become an invisible infrastructure embedded in urban daily life.

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