Building Human Centered Systems Based on Communication Infrastructures: Evidence from Portugal

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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 (or “digital cities and regions”). It is argued that such networks have the potential to attract and mobilize people into a “culture of knowledge” and make public administration and markets more effective, but require, nonetheless, effective infrastructures, incentives and adequate institutional frameworks across time and space. We conclude that networked places need to be designed holistically, coping with change and continuously assessed in order to accommodate humanity. In order to achieve these objectives, semantic grids are discussed in terms of the emerging trends in the design of “digital cities and regions”.

The analysis builds on the co-evolution of human and social contexts at a regional level and of the endogenous process of technical change, namely in terms of information and communication technologies, ICTs. 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 promote the inclusive development of networked places.

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 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, which have been developed through ill-defined *communities of practice,* CoPs.

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, regional 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 human 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]. They 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 in diversified environments, including catching-up regions*? These questions have motivated the work behind the present paper, which has considered the development of case studies in selected Portuguese cities and regions engaged in building digital networks.

In previous papers we have considered the development of the information systems oriented towards building networked places and argued that knowledge networks have the potential to attract and mobilize people in the information society and make public administration and markets more effective [12,13]. This helps promote learning trajectories for the inclusive development of society, requiring, nonetheless, effective infrastructures, incentives and adequate institutional frameworks across time and space [14]. The analysis builds on the need to continuously adapt regional trajectories, both social and technological, and foster the necessary learning capacity of increasingly diversified local communities, referring to social capital as a relational infrastructure for collective action [15], and creation and diffusion of knowledge.

Our previous conclusions derived from observations in different Portuguese urban areas with the ultimate goal of increasing regional competitiveness, by promoting public awareness and participation in decision-making processes. We have argued that the territory is a basic infrastructure that justifies and invites for the construction of several layers of information about cities and regions where people live, visit or do business. In addition, digital city schemes should also encourage the global legibility of the information architecture of the territory and promote broad and informed participation in the decision-making process of the future in its entire influence area and not only within city limits [16].

The remainder of 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, making use of case studies in Portugal. 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 networked spaces.

2. Mobilizing the Information Society through *Digital Cities*

For the first time in human history, the urban population is matching the rural population [17], Figure 1. 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 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, 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%). Also, seventeen megacities, exceeding 10 million inhabitants each, can be found in the world today.

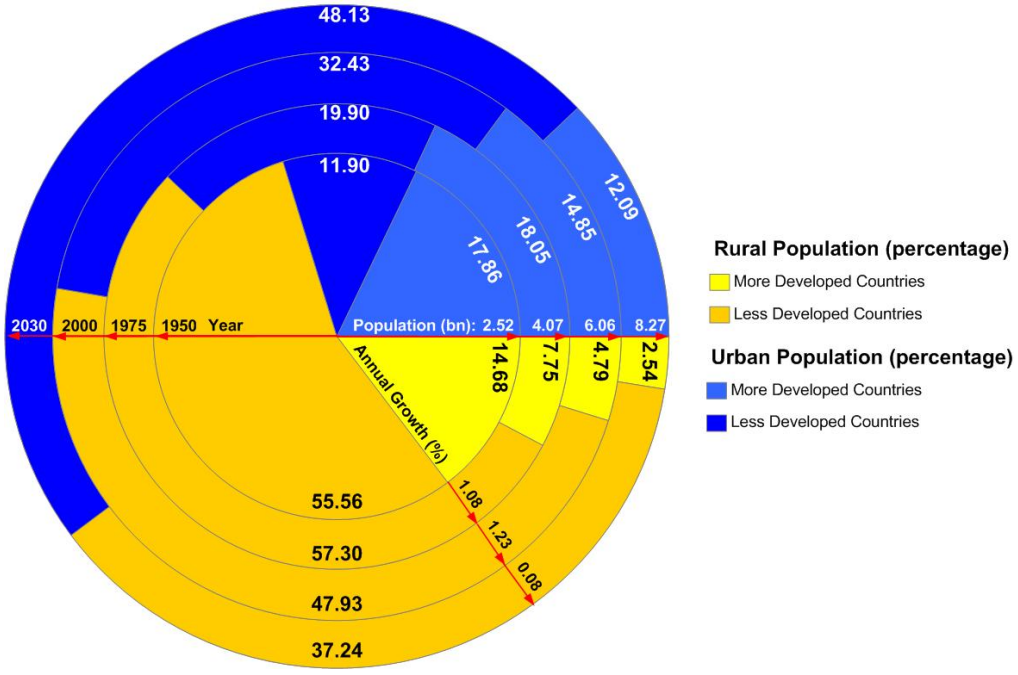


Figure 1 – Evolution of world's urban and rural populations; Source: [17].

The image of the city has evolved accordingly, from socially coherent and spatially circumscribed entities to complex juxtaposition of boundless urban processes [18]. 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 (Regional 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 its counterpart; and the city as a machine of wealth creation [19]. But at the end of the twentieth century, a new paradigm has emerged with Castells' "Informational City" [20]. As pointed out by Susser [21], "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 visions enhance one or another aspect of the urban daily life, most agree that cities are characterized by dense and heterogeneous singularities of people and buildings in a specific place, or as proposed by Spiro Kostof [22], "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 [23], one of the main enablers of localized innovation and entrepreneurship. As pointed out by Zook [24], "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 novel imagining 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" [25].

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. The goal was to provide an electronic space for political discussion and participation in the ten weeks that preceded local elections. The initial success (10,000 registered users in the first weeks) quickly transformed a “grassroots and subsidized initiative [...] into a non-subsidized not-for-profit organization, with a turnover (in 1997) of about $ 500,000, and employing (in 1998) more than 25 persons (all together filling 17 full time positions)”. The revenues, at that period, came mainly from services like consulting, hosting, sponsorships, and advertisement. Despite the increasing number of registered users (150,000 by January 2001), the demand for these services declined steadily due to, among other factors, the ever growing competition, and, consequently, the sustainability was threatened. The lack of funding prevented some strategic functional or technological upgrades and contributed decisively for the downward spiral that forced some of its most important assets to be either discontinued (content production) or sold (school portal, Internet access and Web hosting services) until the DDS became a stripped-down commercial Internet Service Provider in 2001 (http://www.dds.nl/). As brought out by van den Besselaar [26], “…similar initiatives were undertaken in the Netherlands. Some of these failed, while others remained much smaller, less developed, and less visible. This indicates that the success of the DDS was highly contextual, based on timing, and on the local Amsterdam cultural setting” [see also27,28].

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” [25, 29]. A three-layered model, strongly connected with the real city, was proposed and consisted of three layers, namely: (a) information layer (real-time data acquisition and databases); (b) interface layer (2D maps and 3D virtual reality); and (c) interaction layer (community building and communication). The first phase of the Kyoto Digital City was developed and housed in the NTT Open Laboratory, aiming to “promote research without restraint”, and where the subjects “were discovered while doing it, the research papers were published afterwards” and the “norm was “move then think”. Nevertheless, as clearly noted by Ishida [25], this open environment failed to solve

institutional issues, including research ownership, and “this misunderstanding terminated the project, which was initially supposed to run for three years, after one and a half years”. Then, the Digital City Kyoto Experimentation Forum was founded in 1999, including universities, local authorities, other organizations and individuals. Its web presence (http://www.digitalcity.gr.jp/index-e.html), the “Digital City Kyoto Prototype”, provided 34 services divided in four categories (information, community, showroom, and laboratory), including personal websites, a georeferenced city guide (i.e., *GeoLink*, with more than 5,000 links) and a virtual representation of shopping streets (i.e., *3D Kyoto*). After two years and only 150,000 accesses, this second phase ended in September 2001.

The two projects mentioned above has influenced over the last decade many city developments and guide “digital city” projects over the world. However, context creation, mobilization, sustainability and adequate organizational and institutional frameworks seem to be critical while designing, implementing and exploiting digital cities [12] and have raised the process of looking for best practices. The question is that analysis has shown us to reject the notion of the “one best way” and that networked places need to be designed holistically, coping with change and continuously assessed in order to accommodate humanity. The following paragraphs reinforce this hypothesis by discussing Portuguese experiences in mobilizing the information society at urban and regional levels.

2.1 Building the evidence: Case studies from Portugal

Portugal explosive urbanization rate, as indicated in Figure 2, was one of the motivations to study the co-evolution of urban development and telecommunication services and infrastructures, in terms of a knowledge related view of the territory.

The evidence presented in this section is built on the analysis of sample projects for digital cities and regions in Portugal, which have been structured around the electronic provisioning of local government administrative services, complemented by some pilot projects in areas such as e-business and telemedicine [13].

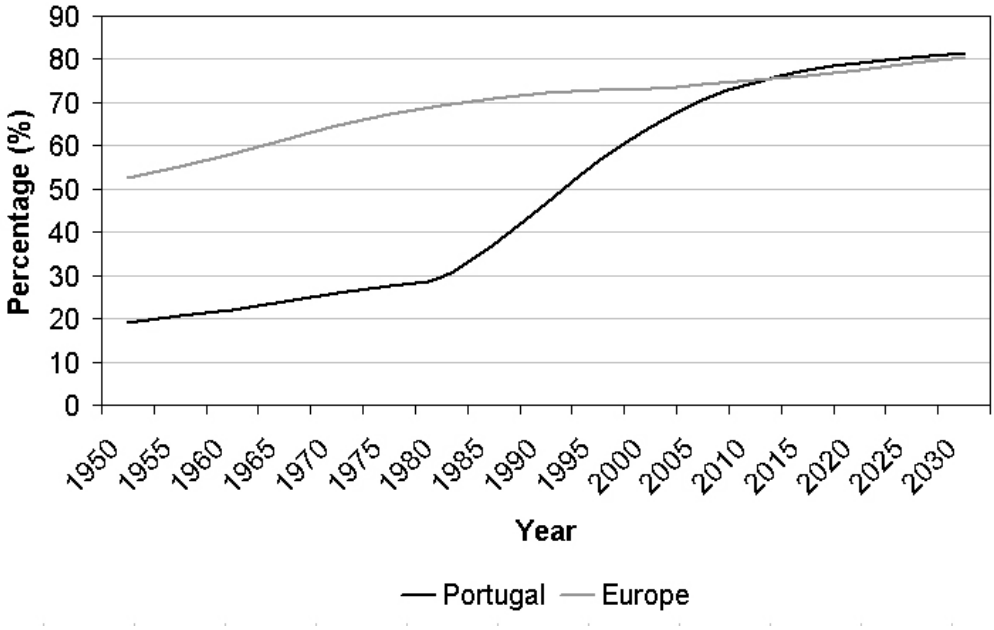


Figure 2 – Percentage of population living in urban areas for Europe and Portugal for the period 1950-2030 (estimates since 1991); Source: [17].

The first experiences in Portugal with digital cities started in 1998 through a program jointly funded by the Portuguese Government (who contributed with 25% of the total investment) and the European Union (75% of the total investments through the European Regional Development Fund). Private investments were insignificant. The program involved 5 small and mid-sized cities (Aveiro, Bragança, Guarda, Marinha Grande, Castelo Branco) and 2 rural regions (Trás-os-montes and Alentejo), as identified in Figure 3, aiming to: (a) improve the quality of life in cities; (b) contribute to development of peripheral areas; (c) improve local economy and employment; and (d) fight info-exclusion and help citizens with special needs [30].

Alentejo and *Trás-os-Montes* are remote agricultural regions, among the least developed in Portugal and Europe, sparsely inhabited by an aging population. Both projects were designed to create new opportunities for the local population, mitigate social and economic disparities, promote regional networking and provide public administration electronic services to peripheral local parishes.

Aveiro is developing a true innovative and entrepreneurial image, in particular connection with the local university and the local branch of Portugal Telecom, which includes important research and development activities. On the other hand, *Marinha*

Grande is particularly engaged in traditional, labour-intensive industries and the digital city project has been particularly promoted through the industrial network associated with the local moulds industry. Both these two projects invested mainly on local competitiveness and competence building.

Bragança, *Guarda* and *Castelo Branco* are peripheral cities with relative regional significance. Their approach was to support the adoption of information and communication technologies by individuals, firms, associations and local government and other public organizations.

In terms of regional penetration, the projects listed above covered about 11.30 % of the total Portuguese population (10.44% of the population under 15 years of age) 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 being nonetheless always led by local municipalities. Local higher education institutions were particularly involved only in a limited number of projects (Aveiro, Bragança, Trás-os-Montes).

It should be noted that, at least for the initial projects analysed here, the institutional framework established by the central government was quite flexible and fostering local voluntary initiatives. It was based on the simple provision of guidelines focused on providing content and services related to local public administration and to specific activities with social implications (e.g., healthcare), economic impact (e.g, business-driven corporate networks for regional competitiveness), and aimed to promote cultural contents [31, 32, 33, 34]. Initiatives to mobilize and promote the adoption of the Information Society were part of various applications, although not always considered at the required level, at least beyond that given to the implementation of infrastructures [33].

Bragança Digital focused on creating basic ICT infrastructures and wireless networking environment for local government buildings, health institutions, educational institutions, and local employment agency to provide information and services to local citizens. Other initiatives included the provision of local products (www.rural.net), health, educational and e-business activities [34].

Figure 3 - Identification of main projects for the specific development of digital cities and regions in Portugal, as established over the period 1998-2000, making use of European structural funds;
Source: [13]

Guarda Digital was promoted by and organization formed by the municipality, local educational institutes, associations" and the incumbent telecommunication operator. It included pilot projects in healthcare e-business, tele-working and educational initiatives [35].

Castelo Branco Digital aimed to connect all public institutions (municipality, social security and health institutions) and local associations (sports, culture and business) to provide an integrated information network to citizens and tourists. For example, it has included the provision in rich media of old Portuguese theatre contents [36].

Marinha Grande Digital, as managed by the local municipality and the Technological Centre associated with the moulds and plastic injection industries, focused on creating an Extranet to provide business-related (mould, plastics and glass) content and services and on facilitating communication among companies and clients. Other

initiatives included a centre of advanced telecommunications to promote the use of the Internet [37].

Projects	Physical Infrastructures		Content (non-physical infrastructures)		Context (e)
	Networking and Connectivty (a)	Information Systems (b)	Information Services (c)	Interactive Services (d)	
Aveiro	Local health institutions communication network; Internet access in public schools; People with special needs	Local public administration management information systems; Justice court Intranet; GIS	City guide; Entertainment, Arts & culture initiatives; Local government website	e-business, Agriculture; Job opportunities; Environment; Teleworking	Community building based on city metaphores
Bragança	Municipality communication network; Internet access in public schools	Municipality management information systems; GIS	City guide; Local government website	e-business; Telemedicine; Agriculture	
Guarda	Internet access in public schools		Local government website	e-business; Telemedicine; Teleworking	
Marinha Grande	Advanced telecommunication demonstration centre; Internet access in public schools	Local industries Knowledge network (Glass, moulding and plastics)			Mobilization of firms and public institutions for the use of ICT
Castelo Branco	Municipality communication network; Internet access in public schools		City guide; Local government website; Art & culture		
Trás-os-montes Digital	Internet access in public schools	Content management platform	Regional Portal	Telemedicine; Agricultural Network; Job opportunities	
Alentejo Digital	Intranet for 47 municipalities	Content management platform	Regional Portal	Job opportunities	

Table 1 - Sample "Digital City" projects analysed in Portugal (1998-2000); Source: [13].
(a) Networking and connectivity includes communication networks and Internet access.
(b) Information Systems includes technological components that store and process data like data bases, electronic mail, ERPs, management information systems, content management, application serves and business intelligence software
(c) On-line presence or downloadable forms
(d) Electronic form submission or interaction through the web
(e) Mobilization and context building initiatives

Trás-os-Montes Digital included regionally-based web contents (i.e., www.espigueiro.pt), managed by the local Polytechnic, that aggregates content and services of 31 municipalities. The portal is still managed by the local university and includes business and employment opportunities, geo-referenced information,

healthcare facilities and technologies to coordinate medical services in rural areas. An important feature of this project is the support network constituted by 84 service centers scattered throughout the region that provide public Internet access, as well as human support to help citizens' interactions with new technologies [38].

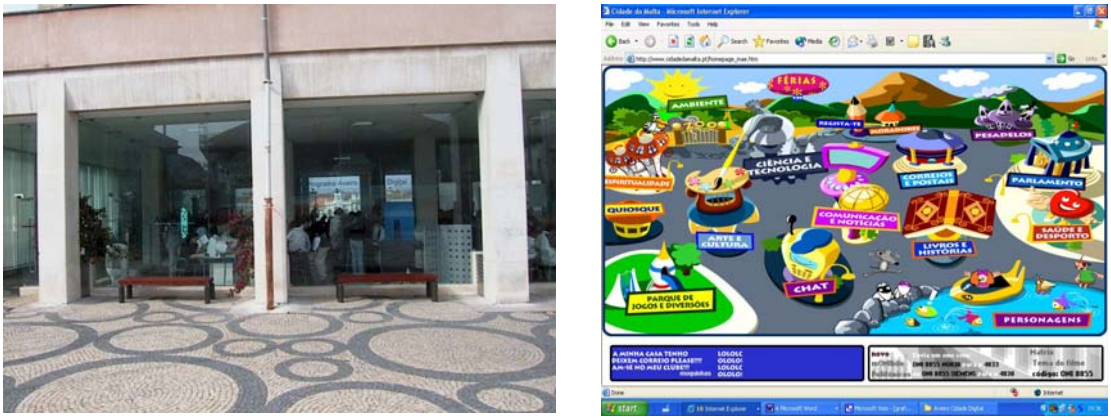
Alentejo Digital brought together 47 municipalities and 3 regional agencies to create a regional information network to provide services and territory-related content to citizens and local firms through regional web-based contents. The main objective was to enable local government teams to learn, use and promote new technologies, namely computer network management and digital content production and publishing. An Intranet was set up linking all municipalities and regional agencies to enable the necessary collaborative work environment. About 50 people were recruited, mostly from local unemployment lists, to work on the project that lasted until July 2001 [39]. Most of those people worked as local agents, based on each one of the town hall facilities of all the 47 municipalities involved, who proactively produced, collected or published relevant local content in the portal. Although they did not work directly with the general public, they were a very important factor of Internet diffusion in the territory covered by the project.

2.2 The case of the *Aveiro Digital City*

Within the broad range of digital city projects considered at international level [16], Aveiro Digital represents an interesting case study in that it has comprised diversified initiatives promoted and coordinated by an autonomous organization formed among the local government, the local University and the incumbent Telecommunication operator, PT Telecom. It represented the result of a long preparation effort and provided the opportunity to evaluate concepts and dynamically testing ideas, involving a limited but well informed group of people [32].

Aveiro is a seaport in the north of Portugal, located at the Vouga estuary, with a population of approximately 55,000. The city's innovative and active character, although recent, draws from the singular institutional framework established in close collaboration between the local university and the local business environment, mainly

driven by the national telecommunication operator. Following the launch of the first Digital Cities 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 [31, 32, 33]. 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 is expected to be some four times larger than the previous investment.



a) Aveiro Digital City Centre (source: http://digipraca.aveiro-digital.net/)

b) Interactive learning website for kids (http://www.cidadedamalta.pt/)

Figure 4 - Sample infrastructures and contents provided through "Aveiro Digital"; Source: [12].

After a troubling start – budget allocation negotiations and bureaucracy caused lengthy delays, mostly for over than one year, in both 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, as illustrated in Figure 4. Emphasis was given to infrastructures and

digital contents, including local e-government, e-health, e-business and entertainment, as listed in Table 2[1].

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 [33]. 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.

Nonetheless, during 1999-2000, Aveiro Digital City made available 446 personal computers to diverse public and private organizations, published 8 CD ROMs and 32 websites, supplied 73 interactive services, and trained 529 people, as listed in Table 6. The number of Intranets and Extranets users exceeded 3.000 people in different public and private organizations and the Aveiro Digital City Website (www.aveiro-digital.pt) accounted for a monthly average of 4,700 visitors.

The main question raised by local people involved in the project has been consistently associated with the structure of public financing and the conditions for long term sustainability, mainly due to the fact that when the limited public funds dried up some of the projects came to a close, while others kept their presence in the Internet

[1] The projects in Table 2 were chosen among 70 applications in a call for ideas competition held in June 1998. 42 were approved, predominantly from public institutions or not-for-profit organizations and 37 projects were actually implemented.

although rarely updated. Moreover, the funding concentrated mostly on the inputs of a long change process, namely infrastructures, information systems and ephemeral content, giving little consideration to the improved understanding of forms of mobilizing the population at large.

Intervention Areas	Activity	Related Websites
Communitiy Building	Internet access points in 13 public buildings and 5 cultural or social organizations	digipraca.aveiro-digital.net
		digibairros.aveiro-digital.net
e-Government	Aveiro Municipality geographical and administrative information systems	n.a
	Water and sewage municipal services one-stop shop	www.smaveiro.pt
	Water quality sensing and monitoring system	n.a.
	Justice Court Intranet	n.a
Education	Computers, Internet access and ICT training in local basic and secondary schools for teachers, parents and students	veraria.aveiro-digital.net
		cspveracruz.aveiro-digital.net
		membros.aveiro-digital.net/esvir
	Cybergames and interactive leaning applications	Tictac.aveiro-digital.net
		www.cpj.ua.pt
		www.cidadedamalta.pt
Environment	Biology knowledge network about local biodiversity, molecular biology and estuary ecosystems	www.biorede.pt
Health	Computers, Internet access and ICT training for the local public health professionals	saudenet.aveiro-digital.net
Social Cohesion	Computers, Internet access, ICT training and focused information for low income families and people with special needs.	Resea.aveiro-digital.net
		portal.ua.pt/projectos/meu
		bancoalimentar.aveiro-digital.net
	Teleworking	portal.ua.pt/projectos/ist
eBusiness	Computers, Internet access and ICT training for 20 SMEs, including basic digital services provisioning	n.a.
	Port authority telecommunication infrastructure, management information system and Extranet for services and products suppliers	n.a.
	eCommerce service centre (Internet and public access Kiosks) for local shops	n.a.
	On-line shopping mall	http://www.aveiromegastore.com
	Livestosck information network	n.a.
	eLearnng and interactive training	www.ibjc.pt
Entertainment, Culture and Arts	Interactive TV pilot project	n.a.
	On-line news	www.netpaginas.pt
	Digital arts workshops	oadgv.aveiro-digital.net
	Interactive listening music CD Rom (Mozart)	www.orquital.ua.pt
	12 public access information Kiosks (city guides, tourist information, maps, etc.)	n.a.
	History, culture, art and nature from Aveiro	aveirana.doc.ua.pt
		camarinha.aveiro-digital.net
		www.net-moliceiro.inovanet.pt
		ciadanca.aveiro-digital.net
		www.terravista.pt/copacabana/2800

Table 2 - Main digital contents included in the first phase of the Aveiro Digital City Project
Sources: [31, 32, 33] and http://www.aveiro-digital.pt/

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 form 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 [12].

2.3 The important role of communities of practice in digital cities: fostering learning networks

The evidence of the projects discussed above show that we must extend our analysis from a technocratic paradigm of technical change and look at broader system design fostering societal developments. In particular the experience of projects such as those developed in the cities of *Marinha Grande* and *Aveiro* clearly shows the important mutual relationships that specific project-based communities have on the facilitation of network societies, but also the fact that the implementation of digital cities may significantly improve the efficiency of those communities. In the following paragraphs, we extend this evidence and argue that the success of digital cities rely on the specific development of communities of practice, CoP´s, namely those integrating knowledge networks.

We refer to project-based communities, oriented to specific social and economic goals, that will benefit, and gain from, digital networks if particularly challenges by knowledge-based activities. In the case of *Marinha Grande* the evidence is that economically-oriented networks based on mould-forming companies has particularly launch business networks, which still require long-term processes and continuous funding, as well an adequate institutional setting. In this case, it should be noted the role of the related industrial association and technology centre in promoting the

necessary links and networking facilities, which again support our previous analysis of the need to consider basic framework conditions.

In a different scale, but also using relatively reduced level of incentives, namely at an international scale, the evidence provided by the *RuralNet Project* developed in the city of *Bragança* also shows the critical importance of project-based mechanism to support and sustain digital cities. But of specific interest in our context, are some of the activities developed in *Aveiro*, in that knowledge-based activities could promote and sustain digital networks well beyond the period under which public incentives were made available.

The reason why knowledge-based activities are particularly prone to foster and sustain digital networks is because they will increasingly rely on "distributed knowledge bases", as a systematically coherent set of knowledge, maintained across an economically and/or socially integrated set of agents and institutions, as discussed by Smith [40] and Conceição et al [14], among others. The relevance of considering distributed knowledge bases across economically and/or socially integrated set of agents and institutions leads us to the concept of social capital. In the broadest sense, social capital is associated with the "social capabilities" [41] that allow a country or region to move forward in the process of development. In a more sophisticated treatment, Coleman [42] states that social capital is "a variety of different entities, with two elements in common: they all consist of some aspect of social infrastructure, and they facilitate certain actions of actors—whether personal or corporate actors—within the structure." The relationship of social capital for the economic performance of nations was recognized by Olson [43] and North [44], in broad descriptions of the process of development.

Referring again to the evidence provided by some of the projects discussed above, namely those at Aveiro, the role of higher education institutions appear to be particularly important in fostering network activities, namely in the form of knowledge-based communities. Following the analysis of Castells and Hall [45], "it takes a very special kind of university, and a very specific set of linkages to industrial and commercial development, for a university to be able to play a role it often claims to play in the information-based economy". Definitely, those technical universities that are pure teaching factories, or work under a bureaucratic structure, are unlikely to

act as generators of advanced technological milieu. Again, this recalls our attention to the role of institutions in planning digital cities and promoting their impact.

Still in this context, Bill Mitchell [46] argues that the most obvious advantage of digital networking is that it provides an efficient way of "aggregating specialized expertise" through "common access to project databases, compatible software tools, and advanced telecommunication capabilities". But, he emphasizes that "it does little about the problems of creating trust and confidence, and of building intellectual and social capital for the long term", requiring the development and maintenance over weeks and months of "project-based learning communities" looking at a common and complex target. Long term collaborations can provide a more permanent framework of online resource-sharing, and examples of such an initiative shows the need to bring scale and diversity, beyond time. Based on this example, Mitchell concludes that we should look beyond the popular idea of learning communities and seek to produce communities that "motivate and sustain creative discourse yielding original intellectual products such as architectural and engineering designs", the so-called "creative communities".

A final remark associated with the form and role knowledge networks may play in the process fostering network societies, should be discussed in terms of the evidence provided by the Program "Ciência Viva" in Portugal, namely in association with some of the projects discussed above [47]. It refers to specific networks formed among basic and secondary schools with university groups and research centres through project-based activities oriented to promote a culture of learning. Beyond the critically important role of this type of activities, as explained by Ziman [48], among others, taking Pine and Gilmore's contentions [49] about what they termed "the experience economy" and the role experiences play in building stronger and more personal relationships in the corporate world, our argument is that schools, and universities in particular, must deliver authentic experiences to build and encourage sustainable and entrepreneurial growth. Pine and Gilmore explore the idea of experiences as a fourth economic offering, as distinct from services as services are from goods, but one that has until now gone largely unrecognised. While services may be considered as a set of intangible activities carried out on behalf of a person, experiences are memorable events that engage that person in an individual way, so that they determine and guide transformations. Experiencing entrepreneurial processes at the school (and the

university, in particular) thus sets the stage for the societal transformations required to progress successfully towards innovative societies.

From the analysis above, it is clear that knowledge-integrated communities may develop over different institutional, thematic and social frameworks and Table 3 summarizes the evidence provided by the various projects analysed.

Driving factor	Sample Experiences	Remarks
Scientific	*Biorede* - Biology knowledge network about local biodiversity, molecular biology and estuary ecosystems launched at Aveiro (www.biorede.pt)	Website developed and managed by Research Centre
Education / Training	"Engineering in Portugal", providing historical data and information for Basic and Secondary Schools, as well as university students (http://www.engenharia.com.pt/)	Learning materials and information exchange between experts, teachers and students; Website managed by Research Centre
Public Health	Health information and communication network of the Bragança Digital City extension services (www.espigueiro.pt/servico_cooperativo/servico_coop_puh.html)	Portable computers and Internet access to foster the communication and information exchange between doctors and patients
Managing Public Risks	Water quality monitoring and public diffusion system (www.simoqua.pt)	Raise public awareness about water quality, flooding and other public risks
Corporate strategy and competitiveness	Marinha Grande local-industry (moulding, plastics and glass) network (www.marinhagrandedigital.com/)	Extranet managed by Technological Centre

Table 3 - Typical experiences fostering knowledge networks as identified in the various digital city projects analysed and other sample initiatives; Source: [12].

3. Discussion: the social and cultural shaping of ICTs

Our discussion is framed within three main levels of analysis, namely infrastructures, contents and context, which are comparable with those schemes that consider five mains aspects, namely: infrastructure, access, applications and services, digital content development, and ICT skills development [50]. In fact, the evidence provided by Lena Tsipouri throughout Europe leaves us to jointly consider the first two levels under infrastructure, as well as to join application and services and digital content

developments into a single level of analysis. In addition, we broaden the scope of the so-called ICT skills development to include other contextual issues and local characteristics of communities of practice.

In previous papers we have focused our analysis on the type of incentives and institutions required to allow the mobilization of ICTs [12, 13]. In this paper we focus the analysis on the cultural and social shaping of these technologies and argue for the need to consider human-centred infrastructures and systems. This is because 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, being shaped by and shaping 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 have not always been considered in many different situation throughout the world, as acknowledge 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 those 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” [1]. 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” [11].

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 design digital cities described in section 2 above need to be reconsidered. Table 4 describes main implications and requirements of emerging trends, so that the vast majority of potential late adopters are inclusively considered in future digital city projects. As Dertouzos [51] 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 that our machines are easier to use and make us more productive; and insisting that new technology reach many more people”.

Norman [52] 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.

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

Table 4 - Emerging trends in the mobilization of the information society, towards a new generation of "Digital Cities".

On the other hand, the number of potentially connected nodes within urban environments has significantly increased in the last couple of years (see Figure 5), 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 been 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.

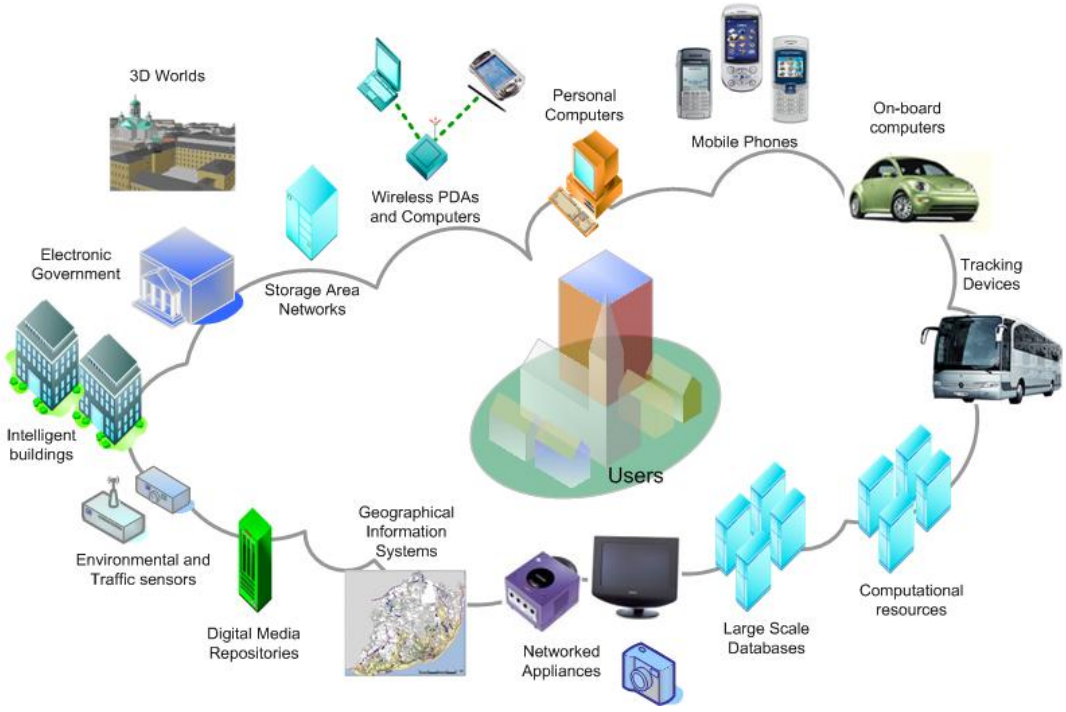


Figure 5 - Grid resources linked together in a "Digital City" infrastructure

Grid computing, as described by Berman et al. [53], 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.

The current grid model has a 4-layered architecture that includes (Figure 6):

1. hardware resources, such as computers, networks, data storage, sensors and other devices that weave the underlying fabric;
2. interoperable protocols, services and applications that virtualize and secure the access to the grid;
3. common grid middleware, tools and services, such as resource allocation and monitoring;
4. Grid applications.

The vertical layers represent new devices, and institutional arrangements to create common policies, grid economy and a open global-area networking [54]. We argue that on top of the current model, an activity-based, human-centred layer of services should be added to help the mobilization process (as a complementary vertical layer). This territory-related additional layer could be enabled by specific knowledge-driven ontology [55], natural language [56] and/or the semantic web capabilities for "handling and support for knowledge processing" [57].

If one considers the broad social and economic context under which digital cities may be facilitated, we must consider the conditions for integrated learning processes. This has led Conceição, Heitor and Lundvall [15] to build on Lundvall and Johnson's learning economy [58] and to discuss the learning society in terms of innovation and competence building with social cohesion. They view innovation as the key process that characterizes a knowledge economy understood from a dynamic perspective, while competence is the foundation from which innovation emerges, and which allows many innovations to be enjoyed. In other words, it contributes both to the "generation" of innovations (on the supply side of the knowledge economy) and to the "utilization" of innovations (on the consumptions side of the knowledge economy). Conceptually, the foundations for the relationship between learning and economic growth have been addressed in the recent literature [59], with learning being reflected in improved skills in people and in the generation, diffusion, and usage of new ideas [60].

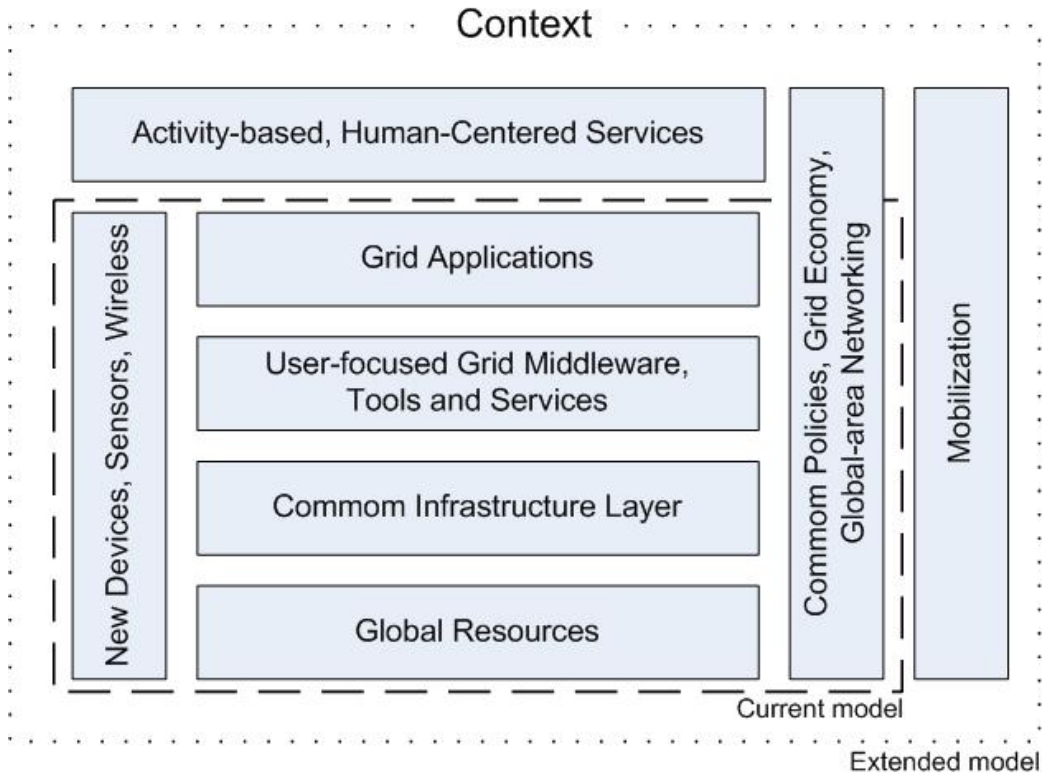


Figure 6 - Layered architecture of a semantic grid enabled *Digital City*; modified from [53].

Learning can occur in many shapes and forms, some of which are informal, some formal. As described before, the institutional framework that comprise the national and regional systems of innovation formalize the technological infrastructure critical to generate the learning processes for individuals, firms, and nations, that ultimately lead to long-term development. Thus, looking at a particular set of organizations, their capabilities and related institutions, provides important lessons for development.

The analysis above is broad in scope and considers network societies as wide social and economic processes, which we argue occur across time and space and require the dynamic adaptation of infrastructures, incentives and institutions, in a way that calls our attention for the need to foster learning societies. However, the evidence of the projects discussed in this paper show that we must extend our analysis to other aspects of the learning society. This is because the experience of projects such as those developed in the cities of *Marinha Grande* and *Aveiro* clearly shows the important mutual relationships that specific project-based communities have on the facilitation

of network societies, but also the fact that the implementation of digital cities may significantly improve the efficiency of those communities.

Within this perspective, our analysis calls for policies that consider long term approaches of dynamic environments, which require to be continuously monitored and evaluated. Specific incentives for infrastructures should continue, but articulated with the need to foster knowledge-based adaptive human centred environments as drivers of larger communities of users. This requires a continuous pubic effort, but also a better understanding of the effectiveness of the mix of public support mechanisms and private incentives for the development of digital cities.

4. Conclusions

The co-evolution of urban environments and information and communication technologies is analysed in terms of the social and cultural shaping of information technologies and related uncertainties for their application to regional and urban contexts. The analysis is based on observations in different Portuguese metropolitan areas 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. It is suggested that knowledge driven communities as particular forms of communities of practice are important drivers of larger communities of users.

Our analysis led us to suggest that while the role of communities of practice needs to be re-examined, the cultural and social shaping of information technologies requires the specific development of human-centred systems. We refer to “edge to core” strategies for the next generation of digital cities.

Our 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 a invisible infrastructure embedded in urban daily life.

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Over the past year, the Communications Sector has made significant progress in assessing risk to its critical infrastructure/key resources (CIKR). The Communications Sector, a partnership between the Communications Government Coordinating CouncilÂ During this reporting period, the Communications Sector heavily focused on the completion of the Communications National Sector Risk Assessment (NSRA) to meet the goals of the National Infrastructure Protection Plan (NIPP) and the CSSP. The NSRA identifies national level communications architecture elements that are at elevated risk and serves as a baseline to prioritize the communications infrastructure.