Smart Cities as Innovation Ecosystems sustained by the Future Internet

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1. Introduction

Larger cities of today are confronted with immense problems in terms of development, inclusion, housing, transport, climate, infrastructure, security and many more. The current economic crisis is even making it harder for cities and their citizens, neighbourhoods and businesses to realize their goals, and many cities are in a state of decline. Smaller cities in rural areas face the implications of ageing population in combination with economic downturn[1]. At the same time the city also represents a promise: a vision of freedom, creativity, opportunity and prosperity. More than half of the global population is now urban and projections estimate that this percentage will even grow towards 70% around 2050[2]. In this context, the concepts of "Smart City" in relation to the "Future Internet" represent technology driven visions and solutions. The challenge is to redefine the Smart City as an environment of innovation, empowerment and participation of citizens, businesses and other stakeholders in **shaping** their future, through the choices they have and decisions they make. The challenge is to focus on **change and transformation** towards a Smarter City in the sense of a change towards **shaping** a better and more participative, inclusive and empowering city, instead of imagining an ideal future vision[3].

Aim of the White Paper

This White Paper focuses on how European cities are currently developing strategies towards becoming "smarter cities" and the lessons we can draw for the future. Such strategies are based on an assessment of the future needs of cities and innovative usages of ICTs embodied in the broadband Internet and Internet-based applications now and foreseen for the future. These strategies are also based on a new understanding of innovation, grounded in the concept of open innovation ecosystems, global innovation chains, and on citizens' empowerment for shaping innovation and urban development. Partly these strategies include the development of new types of innovation in urban areas. These new ways of innovation are characterized, firstly, by a high level of citizen involvement in co-creating Internet-based applications and services in all sectors of the economy and society; secondly, by the emergence of new forms of collaboration among local governments, research institutes, universities, citizens and businesses (e.g. Public-Private-People Partnerships). Such strategies and the resulting urban "innovation ecosystems" are becoming increasingly relevant given the urgent need to tackle growing social, economic and societal issues that cities are currently facing in a context of economic woes while simultaneously many improvement opportunities are offered to cities by new technologies and approaches to innovation.

This White Paper investigates smart city strategies based on a collection of smart city case studies and a series of workshops in which major topics regarding smart cities were discussed. The case studies aim to analyze the currently emerging strategies, policies and technological opportunities, to identify how the opportunities of ICTs and the future Internet are being explored, and how these can be realized in the future driving the socio-economic development of urban areas. The cases also address how cities are redefining their innovation policies and how they are starting to experiment on citizens' involvement within the context of open innovation. In this respect, the cases present

[1] K. Pallagst et al. (2009), "The Future of Shrinking Cities – Problems, Patterns and Strategies of Urban Transformation in a Global Context".
[2] Scientific American, September 2011: Cities – Smarter, Greener, Better.
[3] This view reflects the role of cities understood as co-creative innovation environments, as "Civic Laboratories" (see also the report "The Future of Cities, Information and Inclusion" from the Institute for the Future (2011). There is also a relation with the field of science, society and technology studies addressing "social shaping of technology" and "structuration" (Giddens, Orlikowski).

lessons learned that are of interest to smart city project stakeholders from the perspective of policy development. Based on our findings, we draw conclusions and propose a roadmap towards smarter cities which aims to be of interest for all stakeholders involved.

The FIREBALL Project (2010-2012)

This White Paper is one of the main outcomes of the FIREBALL project (www.fireball4smartcities.eu), a Coordination Action within the 7th Framework Programme for ICT, running in the period 2010-2012. The aim of this project is to bring together communities and stakeholders who are active in three areas, namely: research and experimentation on the Future Internet (FIRE); open and user-driven innovation (Living Labs); and urban development. The goal is to develop a common vision and a common view on how the different approaches, methodologies, policies and viewpoints in these areas can be aligned to boost innovation and socio-economic development of cities. The underlying view of FIREBALL is that cities constitute innovation playgrounds, hence, may act as "agents of change". Open innovation and citizens' engagement aim to bridge the gap between the R&D of Internet technologies and actually experimenting and using Internet-based applications in cities. These applications and services are intended to bring societal and economic benefits in areas such as healthcare and independent living, enterprising and SMEs, participative government, energy efficiency, environment and quality of life.

FIREBALL aims to contribute to the creation of "Internet-based innovation ecosystems" that are more effective, open and user driven, where methodologies, approaches and resources of the constituencies can be aligned and shared more easily and effectively, benefiting rapid adoption of Internet services, and economic and social development in cities as well as stimulating more effective networking and experience sharing among cities to accelerate a wider adoption. The role of cities in this respect is of profound importance as they should be considered a key driver of innovation in Future Internet applications and services. Forming Internet innovation-ecosystems across existing constituencies will increase the prospects to overcome barriers in the take-up and adoption of services and addressing the lack of interoperability and absence of open innovation platforms.

The Concept of "Smart City"

Cities and urban areas of today are complex ecosystems, where ensuring sustainable development and quality of life is an important concern. In such urban environments, people, businesses and public authorities experience specific needs and demands regarding domains such as healthcare, media, energy and the environment, safety, and public services. These domains are increasingly enabled and facilitated by Internet-based applications, content management platforms and broadband infrastructures. Therefore, cities and urban environments are facing challenges to maintain and upgrade the required infrastructures and establish efficient, effective, open and participative innovation processes to jointly create the innovative applications and services that meet the demands of their citizens. In this context, cities and urban areas represent a critical mass when it comes to shaping the demand for advanced Internet-based services and experimentation in a large scale open and user driven innovation environments.

The term "smart city" has attracted a lot of attention in recent years. Since the end of the 1990s many cities have initiated smart city initiatives. In the Digital Agenda of the European Commission, cities are considered as innovation drivers in areas such as health, environment, inclusion and business. The concept of smart cities captures different meanings, and we must look beyond a superficial use of the term for pure city marketing purpose. We aim to shed more light on this concept of smart cities, in particular focusing on the defining role of the Internet and user-driven innovation. A useful definition to start with is to call a city "smart" when "investments in human and social capital and traditional (transportation) and modern (ICT-based) infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government" [Caragliu et al 2009]. To this, the notion of empowerment of citizens and

"democratizing innovation" should be added [Von Hippel 2005]). Other definitions have tried to identify key domains of smart cities, such as smart economy, smart mobility, smart environment, smart living, smart people, smart governance, and have defined rankings based on measurable underlying indicators. Smart cities can be also understood as places generating a particular form of spatial intelligence and innovation, based on sensors, embedded devices, large data sets, and real-time information and response.

While these definitions are relevant for benchmarking or for placing emphasis on specific development aspects, they are merely based on technology-led views. There is a need for research on effective strategies of cities to become smarter, taking into account the particular socio-economic context and urban development objectives, and on approaches mobilizing the participation and intelligence of citizens, businesses and societal organizations.

Content of this White Paper

This White Paper addresses several aspects that are critical for understanding the "smart city" concept and the current progress in this area. Based on cases studies and foresight reports we aim to shed light on how the concept of "smart city" is currently adopted by European Cities and what the ambitions and expectations are in using this concept. We investigate the drivers and bottlenecks that influence the transformation towards a "smart city". Underlying approaches to smart cities are discussed, both in terms of the strategies and planning approaches. From this point of view, we explore the conditions that must be established to stimulate the transformation towards smart cities, and the resources that are available or should be made available such as investments in broadband networks and in smart applications, as well as in the capabilities to innovate. This also points to the changing structures and processes of innovation and city development. Interestingly, we see a tendency towards more decentralized and bottom-up approaches to planning and innovation. Innovation ecosystems are characterized by a combination of top down and bottom up initiatives, leading to networking and collaboration among stakeholders, which eventually extend to real innovation communities. Increasingly, citizens, advanced businesses and local governments act as proactive catalysers of innovation, shaping cities as "agents of change".

2. Drivers and Components of Smart Cities

2.1 Cities and collaboration: the socio-economic component of smart cities

[Porter 1995] in an analysis of inner cities, has emphasized the importance of improving the business environment and employment opportunities based on location advantages, rather than considering the traditional emphasis on social development. While correctly underlining the importance of the business environment that was important in the nineties, from the current perspective Porter's view looks one sided as modern views of social innovation have emerged in pointing out the importance of collaboration and partnerships, community development and citizens participation. The promise of smart cities, linked to smarter and interconnected communities, is strongly brought forward by [Kanter and Litow 2009]. Taking the economic crisis and how that affects cities as a point of departure, the authors emphasize the need to "create smarter communities that are information-rich, interconnected and able to provide opportunities to all citizens". In terms of solutions, they put a lot of trust on smart system technologies such as cloud computing, data warehousing, online collaboration and social media to build smarter cities and communities. While this might be part of the solution, it strongly depends on how the technology is being applied and how it is used to enable citizens and businesses to develop and experiment innovative solutions.

Cities as Complex Social Systems

Cities are complex social systems and many of them experience difficult issues on the social, economic and environmental domains. Tackling economic viability of cities has always been a major issue. Ensuring sustainable development and quality of life are also important concerns for modern cities. A report of the European Environmental Agency [EEA 2009] concerning quality of life in Europe's cities states that although quality of life has improved in many areas, in other domains such as health, quality of life has deteriorated. People, businesses and public authorities experience specific needs and demands in domains, such as healthcare, education, media, energy efficiency, inclusion and the environment, as well as safety and public services. These domains are increasingly enabled and facilitated by Internet-based applications, sensors and embedded systems and infrastructures based on common platforms. Therefore, cities and urban environments are facing challenges to maintain and upgrade the required infrastructures and establish efficient, effective, open and participative innovation processes to jointly create the innovative applications that meet the demands of their citizens. While new Internet-enabled networks and applications start becoming available, which potentially might bring economic and social benefits not only to research communities but also to cities, it becomes more urgent to advance strategies that elicit their future needs and requirements from the perspective of user-driven open innovation. Identifying these needs and requirements elicitation also informs ongoing research, experimentation and deployment activities related to Future Internet and testbeds. Furthermore, it helps to establish a dialogue between the different communities involved in the development of the future Internet and user-driven environments, in order to form partnerships, assess social and economic benefits and discover migration paths at early stages.

Smart Cities therefore need to develop strategies and migration paths regarding how they will make use of available Internet infrastructures, testbed facilities, applications and know-how, and how they will develop public-private partnerships for their access, use, and exploitation. Based on technological opportunities and cost-benefit assessments, cities should develop priorities regarding socially and economically desirable applications responding to strategic objectives regarding economic and social development. Gradually, we will enter a situation where combinations of such assets will be selected and governed by a business model based on partnership and financial viability. Common assets that might be useful in smart city strategies include Living Labs assets, Future Internet Research and Experimental facilities, as well as methodologies, tools and user communities.

A particular point of attention is how these assets can be made openly accessible for both users and developers in order to stimulate experimentation and innovation in becoming part of the innovation ecosystems of cities.

2.2 Innovation ecosystems and living labs: knowledge and institutional components of smart cities

Many cities have endorsed the Smart City concept. The Digital Agenda initiative of the European Commission promotes Smart Cities and the Future Internet [Kroes 2010]. In 2011, the European Commission has also launched a Smart Cities and Communities Initiative, in particular focusing on energy efficient cities of tomorrow. However, there are also medium-sized, small and even peripheral cities that endorse the Smart City concept. Cities seem often to benefit from the concept of "Smart City" for mobilizing citizens, enterprises and research organizations for starting up new development initiatives.
For example, Saint Etienne, a French city, is an example of a mid-sized city that was some years ago in a situation of declining manufacturing industry, has gradually evolved into new economic activities such as optical, mechanical engineering, medical technology and design. This city has developed a tailored smart city strategy by focusing on "design for all" embedded within the "Cité du Design". The Design Creative City Living Lab has adopted scenario based co-creation approaches, working with designers, users and businesses, which are tailored to small and medium sized companies. There are also promising initiatives regarding citizens involvement, such as "Design in the City" and "I participate in the renovation of my school!".

Smart Cities and Living Labs

Living Labs involve users at the earlier stage of the R&D process for co-creating value. A Living Lab is an open research and innovation ecosystem often based on a specific territory and involving a large diversity of stakeholders such as user communities (application pull), solution developers (technology push), research disciplines, local authorities and policy makers as well as investors. While the Living Lab ecosystem, through openness, multicultural and multidisciplinary aspects, conveys the necessary level of diversity, in empowering user communities it stimulates the emergence of breakthrough ideas, concepts and scenarios leading to adoptable innovative solutions. It also allows enterprises, especially SMEs, and users/citizens either as entrepreneurs or as communities to get access to technology infrastructures as well as science and innovation services. The main objectives consist to co-create and explore new ideas and concepts, experiment new artefacts and evaluate breakthrough scenarios in a real life context that could be turned into successful innovations. The social dynamics of such Living Lab ecosystems ensures a wide and rapid spread of innovative solutions through mechanisms such as viral adoption and the socio-emotional intelligence [Goleman 2006].

In this context, domain landscapes of Living Lab and Future Internet research areas [Pallot et al 2010, 2011] as well as the emerging Smart City landscape and policy roadmaps [Schaffers et al 2011], [Komninos et al 2011] were created within the FIREBALL project (www.fireball4smartcities.eu). These landscapes provide valuable insights for articulating Living Labs between the technology push of Future Internet testbeds and the application pull of smart cities.

Innovation Gaps Towards Smart Cities

Discussing the emergence of "intelligent cities", [Komninos 2002] studied three different spatial models for creating innovation environments based on spatial proximity, learning institutions, and physical-digital innovation ecosystems. In a consequent publication [Komninos 2008], the rise of intelligent cities was explained through the integration of human intelligence, collective intelligence for collaboration within cities, and the machine intelligence of digital networks. Many different kinds of applications were identified, related to smart city concepts such as virtual cities, crowdsourcing,

online collaboration, broadband for innovation, people-driven innovation, crowdsourcing sensored data, and smart environments to cite just a few.

In [Komninos and Tarchopoulos 2012], three important gaps are outlined, which cities have to overcome, namely: the digital skills gap that concerns the ability of citizens and companies to master web-technologies and offer solutions over the net; the creativity gap that separates web technologies and applications; the entrepreneurship gap that takes place between digital applications and innovative services. They recommend that cities have to explore various business models and identify the ones suitable for each type of service. Finally, they argue that Living Lab methodologies, social experiments, crowdsourcing, and open city platforms for creating and promoting applications and services may offer good solutions to this end and mobilize creative skills of the entire population of the city. Living Labs for investigating and anticipating how Future Internet technologies will change the way people live in the city and their degree of implication in the urban dynamics. Hence, there is a need for storing and sharing data, which are location and time-sensitive, making them accessible to users through smart devices, web interfaces and physical interface objects.

The Smart City Landscape covers key dimensions of the innovation systems of smart cities, namely: technologies, applications, users and uses, methodologies, actors and policies [Schaffers et al 2011a], [Komninos et al 2011]. The landscape also embodies a map of opportunities for smart city innovations, and for collaboration models in smart city innovation ecosystems. A top-down and systematic view of the landscape identifies and describes different landscape layers, namely: city and urban development, innovation facilities and processes, networked applications and innovations, Internet technologies and services. For each layer, “sub-maps” can be created, such as a map of technologies, map of city applications, and map of smart city policies. It is also important to describe the vertical relations across the layers.

From Dominance of Technology Push Towards Open Innovation

Technology push is still dominant in the actual research agenda. A recent Forrester survey states that smart city solutions are currently more based on vendor push than city government pull. The survey points out that "smart city solutions must start with the city not the smart" [Belissent 2010]. The positive impact of available smart city solutions on European cities has not yet been demonstrated, nor have the necessary funding mechanisms and business models for their sustainability been developed. The domain landscapes of Living Lab, Future Internet research and emerging Smart Cities appear to be a source of insights for researchers in filling the gaps between technology push and application pull. These kinds of landscape also help to reach a broader understanding of the Living Lab movement towards more participative design for Future Internet and Smart City innovation ecosystems. In this context, the Future Internet represents the technology push, Smart Cities represent the application pull and Living Labs form the exploratory and participative playground in between the Future Internet technology and Smart Cities’ applications [Schaffers et al 2011c]. Future Internet research and experimentation represents a technology-oriented approach (Testbeds) that host various service experimentations (application pull). Cities provide many opportunities of attractive exploration and validation environments. Nonetheless, as explained above, a wide empty field exists between the technology orientation of Future Internet research and citizens’ expectations. Hence, the concept of open and user-driven innovation ecosystem, such as embodied in the Living Lab approach, brings the necessary combination of digital skills, creativity and innovation methods that properly bridge the gap between technology push and Application pull.

Whereas the traditional approach to urban development has been mainly top down driven, during the last decade bottom up approaches to innovation and urban development have emerged and become dominant within the intelligent / smart cities paradigm, which are enabled by Internet-based social networks. Crowdsourcing approaches to innovation, city-wide sensor networks to enable networked applications (in e.g. environmental monitoring and traffic control), location-based

applications for all kinds of Apps on mobile devices are current examples of this trend towards decentralized approaches to innovation. The widespread use of the Internet enabling bottom up approaches to innovation and urban development has stimulated citizens' involvement. This may accelerate the actual deployment, use and experimentation of advanced network infrastructures and applications in societal and business domains, such as healthcare & autonomy, energy management and supply chains.

In this respect, [Ratti and Townsend 2011] discuss the role of top down vs. bottom up ("grassroots") initiatives towards smart cities. In their view, the organic growth pattern that can be observed holds some lessons for future smart cities. Central planning often fails to create a city that is tailored to inhabitants' needs and makes too many unjustified assumptions about what people want. It also ignores the enormous creative potential of grassroots efforts and ignores the fundamental goals of social cohesion, quality of life, and democracy. Rather, the authors advocate to bring citizens in the driving seats, which is enabled by the networking and communication technologies that are now available almost everywhere.

2.3 Applications and solutions for smart cities: the technological component

Today, the Internet is widely used for globally communicating and disseminating information. There is a limitless amount of available online resources and tools to share information and develop a better understanding on whatever topics. With the recent advent of user created content, there has been a tremendous expansion in the number of web pages created every day for exposing and sharing societal issues. It is often predicted that the Future Internet, a concept which constitutes an important ICT-theme within 7th Framework Programme of the European Commission, will dramatically broaden both the range of available information and the user's potential contexts and situations [Tselentis et al 2011]. This leads to the quest for Future Internet exploration playgrounds, such as cities and urban areas, to demonstrate the potential for a more efficient use of the Internet resources for the benefit of all. However, open questions remain, such as how to articulate the various relevant Future Internet and Living Lab research streams, how to identify appropriate concepts for supporting the creation of new services by users/citizens leading to smarter cities. Not surprisingly, the Internet evolves concurrently with many research streams such as peer-to-peer, autonomous, content-centric and ad-hoc networking that have already explored improvements on network performance and user experience. Peer-to-peer networking has demonstrated both the feasibility and economic potential for delivering services to millions of users. Cloud Computing is a more recent paradigm for transparently sharing among users scalable elastic resources over a limitless network.

The Digital Space of Cities

The digital space of cities – or, the digital spatiality of cities - is a fundamental component of smart or intelligent cities. As described in previous publications dealing with the architecture and structure of these cities [Komninos 2002, p. 16-17], [Komninos 2008, p. 267-270] the digital space of cities is one of the three fundamental layers of an intelligent city, the hyperspace component complementing the physical city and its innovation ecosystem(s). The digital space of cities can be described as a system composed of four concentric rings. At the centre are the broadband networks, wired and wireless infrastructure, and the access devices enabling communication, data collection and exchange. Then, web technologies enabling data storage, processing, and visualization constitute a second ring. The third ring is composed of digital applications in many different domains of a city for e-government, utilities management, and sustainable development. The outer ring is constituted of e-services, a few selected applications that achieve viable business models and offered on a regular basis as services.

The creation of this digital spatiality is guided by two complementary yet distinct processes. Digital planners and IT developers may use existing solutions - applications on the shelf- which have already being applied in other cities and are recognized as good practice for the management, sustainability

and development of cities. Alternatively, they can try creating something from scratch, developing new solutions and applications using available technologies, research, and creative communities of the concerned cities. In both cases, the deployment of digital solutions rely on a series of information, communication and programming technologies, most of them have becoming available during the last fifteen years. The evolution and change of these technologies is extremely rapid and within a period from the mid 1990s until now we can distinguish three consecutive and overlapping waves of web technologies that have driven the creation of smart cities.

Three Waves of Web Technologies Driving the Digital Space of Cities

Wave 1: The World Wide Web initiated in 1990s and by the end of that year the fundamental web architecture was achieved, including the HyperText Transfer Protocol (http), HTML syntax, the first web browser, URL address, web servers, and the first web pages. A critical step for reaching a wider public was made with the introduction of the Mosaic graphic web browser in 1993. The next year, in 1994, the first commercial web browser Netscape was developed and the World Wide Web Consortium (W3C) was founded to oversee and spread the web standards. By 1996 the commercial web was a reality and companies and public organizations felt the pressure of having a web presence. The era of digital cities was initiated.

The first digital cities, based on the above set of technologies, were mainly static web pages providing information about the urban area thought the combination of texts, data, maps, events, and information services about commerce, recreation and city accommodation. Such digital cities were described as "mirror-city metaphors", as their logic was to offer "a comprehensive, web-based representation, or reproduction, of several aspects or functions of a specific real city, open to non-experts" [Couclelis, p.5]. The innovation that they introduced was about the substitution of certain city activities by new ways of doing things (digital), reinforcing and amplifying city functions, and transforming some urban activities leading to the reconfiguration of the physical city. [Ishida 2000] compared four digital cities that he considered representative of this era: the AOL digital cities collecting tourist and shopping information of the corresponding city coupled with local advertising for vertical markets; the Digital City Amsterdam that was a platform for various community networks and social interaction among citizens; the Virtual Helsinki representing a 3D reconstruction of the entire city; and the Digital City Kyoto, also representing a 3D virtual space enriched with avatars and offering information related to city traffic, weather, parking, shopping, and sightseeing. Ishida concluded that all digital cities were developed upon a three-tier architecture composed of (1) a technology for information integration, (2) a technology for public participation with 2D and 3D graphic interfaces, and (3) a technology supported by agents for interaction with citizens. In addition, a technology for information security, which crossed transversely the previous tiers, became important as more people were involved in digital cities.

The spatial intelligence of cities related to this technology stack was based on advantages of representation and visualization. "One picture is worth a thousand words" reflects this idea that complex environments to be described and understood better by a virtual representation or metaphor. Data mining and online search offered additional capabilities for understanding the complex environment of cities through representations.

Wave 2: An increase in communication bandwidth, wider coverage with broadband connections, and the development of Content Management Systems (CMS) marked a radical change in the web landscape and the digital cities as well. WordPress released on 2003 offered a web publishing platform built on PHP language and MySQL data base. It is an open source CMS, actually the most popular on the Internet. Joomla, released in 2005, offered also a free and open source CMS written in PHP and storing data in MySQL database. Together with Linux they formed the dominant technology stack of Web 2.0, the free open source software LAMP, from the first letters of Linux, Apache Server, MySQL, and Perl/PHP/Python programming languages. The ideas behind the rise of the Web 2.0 were about sharing, both software and content. The Web 2.0 concept introduced a

collaborative and sharing perspective and in many respects it might be considered more as a social innovation than a technological movement. The web became medium on which users interact and collaborate, exchange information, start joint efforts, create virtual communities. The transition to the participatory web appeared with the proliferation of wikis, blogs, social networking sites, media sharing, hosting of web applications, mash-ups, and other collaborative web applications. The critical change was at the user side, as users became both creators and consumers of content and applications.

Web-based collaboration platforms separated programming language and content and simplified the participation of users. They could contribute with content without being involved in software code and programming. Web 2.0 cities followed these trends and new applications for many domains populated the landscape of digital cities. Good examples are SeeClickFix in the area of city governance that enable users to report non-emergency issues for improving their neighbourhood and city; Madri+d in the area of research and innovation enabling collaboration among innovation institutions of a city; Scoop.it for collaborative intelligence at targeted subjects; GoldenDeals and Groupon for marketing and promotion of services locally; Localocracy that gathers citizens, government officials and journalists to discuss and learn about local politics and priorities. Citizens 2.0 report [Barkat et al. 2011] compiled 17 applications of social media that provide inexpensive tools empowering citizens for improving local government responsibility and accountability.

This type of web applications better simulates the fundamental concept of city as social space of agglomeration and collaboration. This time coming closer and working together take place on a digital than physical space. Key concepts for the "digital agglomeration" are those of outsourcing and crowdsourcing, opening and transferring tasks and activities to suppliers and the crowd. The Crowdsourcing Landscape (http://crowdsourcingresults.com) offers a good overview of tools and concepts and how crowdsourcing "could be applied to anything reducible to bits and bytes" [9, p. ix], from prediction markets, idea generation and assessment, distributed innovation, service marketplaces, competition, funding and allocation of micro-tasks.

The spatial intelligence of cities emerging from this type of technology platforms and collaborative web builds on collective intelligence and social capital [Gloor 2006], [Landry et al 2000]. These are fundamental drivers of innovation and problem-solving capability, outlining the intelligence of cities as a collective than an individual achievement. They also pave the way towards Living Labs and other forms of people-driven innovation by introducing the principles of openness, realism, and empowerment of users in the development of new solutions [Bergvall-Kåreborn and Ståhlbröst 2009].

Wave 3: By 2009 the turn to embedded systems and wireless networks marked a new set of technologies for creating the digital space of cities. No better than IBM [9, p. 10] expressed this turn "Smarter cities make their systems instrumented, interconnected and intelligent. Pervasive information and communication technology means that there is much greater scope for leveraging technology for the benefit of cities". Instrumentation means that the working of a city is made measurable by sensors, smart devices and meters; interconnection means that all parts of a city communicate with wired and wireless networks; and intelligence refers to predictive software and modelling for more informed decisions.

The smart city as a digital spatiality embedded into the physical space of cities, into buildings, roads, bridges, and other infrastructures is linked to a new set of technologies, devices and applications:

- Mobile devices enabling ubiquitous access to data and the web.
- Real world user interfaces, QR codes over buildings, RFID, mesh sensor networks, low energy consumption devices.
- 3G wireless networks, future wireless networks, and network interoperability giving 100% Internet usage and penetration.

- Applications for smart phones, iPhones, GPS devices, voice control, augmented reality visualisation over buildings, and AR glasses offering real-time guidance in smart cities.
- Opening of public data over the web, open access to data from sensors, linked data, and semantic web with RDF, SPARQL, OWL, and µFormats for M2M communication of embedded devices.

In this wave, smart cities become part of the future Internet research and future Internet experimental facilities, offering a wide domain of experimentation for the Internet by and for People, the Internet of Contents and Knowledge, the Internet of Services, and the Internet of Things.

Again, the drivers of the spatial intelligence of cities have changed. Within this technology stack intelligence moves out of applications and enters into the domain of data: the meaning of data becomes part of data, data are provided just-in-time, and real-time data enable real-time response. Data and technologies, however, do not lead automatically to new solutions and new services for citizens. The open data urban system demands open innovation models and people-driven innovation models to turn capabilities offered by data and technologies to services and solutions. The Living Labs and other participatory innovation models retain their value to bridge the gap between the technology push of Future Internet testbeds and the application pull of smart cities [Pallot et al 2011].

Widening the Options for Smarter Cities

This continuous evolution of web technologies from the static Web to the Social Web, the Real-Time Web, the Semantic Web, and eventually the Intelligent Web in the near future, widens substantially the options for constructing the digital space of cities. An increasingly complex landscape of technologies, applications, data, business models and e-services is emerging, which is far beyond the management potential of the most informed city authority. How to manage this complexity has become a key issue for most city authorities; and how retaining the value of investments within short cycles of innovation, as each wave of web technologies eventually makes the previous digital solutions quickly obsolete.

3. Cities and the Internet: Strategies Towards Smarter Cities

3.1 Setting up the smart city cases studies

An important part of the FIREBALL effort was focused on analysing how exactly cities in Europe are transforming towards becoming smarter, more intelligent cities. Given the present lack of such case studies, and generally the lack of empirical evidence of what "smart(er) cities" exactly are and how their decision and planning processes function, FIREBALL aims to contribute to a more realistic picture of cities' strategies. The cases-studies were based on interviews and desk research and addressed the cities Barcelona, Manchester, Thessaloniki, Oulu, Helsinki and Lisbon.

This collection of case studies illustrates how bottom-up initiatives and top-down planning processes contribute to the transformation of cities and demonstrate the different environments and cultures in which this transformation takes place. The cases studies form a corpus of observations about current and emerging strategies and policies towards smarter cities and how these try to benefit from the opportunities of ICT-based technologies and applications. Some of them illustrate how cities are working with experimentation infrastructures such as technology testbeds and living labs. They provide an overview of the current situation and future planning and a roadmap towards the development of smart or intelligent urban systems. The cases present lessons learned that are of interest for current and future stakeholders. Specific topics and questions that are covered concern:

- How is the "smart city" concept currently adopted, and what are the ambitions and expectations. How do city stakeholders understand and interpret the concept of "smart city" and how are they defining or describing this concept. What are the key objectives associated to this concept and how are they turned into policy objectives and priorities.
- What is the current state of affairs of the city functioning as a "smart city". What types of broadband infrastructure, web applications, online services, and smart urban environments have been implemented. What are the policies, programs, collaborations and partnerships, activities and initiatives related to smart cities currently functioning. How are they managed, as separate projects or common initiatives. What are the drivers and bottlenecks influencing the transformation towards a "smart city". What is the driving force underlying the transformation towards a smart city. What are the factors hindering the transformation towards a smart city.
- What are the characteristics of the city innovation ecosystems that are involved in smart city strategies. Which networks of collaboration between stakeholders are activated and which innovation communities involved. Which open data platforms were actualized for the development of open solutions, open source or not or preference for commercial or ad-hoc solutions.
- Which strategies, policies, infrastructures and other conditions have been established to stimulate the future transformation toward "smarter cities". Which are the vision and strategy, policy programs, organizational capabilities related to smart cities. How governance is exercised and should be adapted. Which mechanisms are in place for the participation of actors such as SMEs, users, open source contributors and businesses.

A special issue of the Journal of the Knowledge Economy (Vol. 3, No. 1, March 2012) presents four of the FIREBALL case studies: Barcelona, Manchester, Thessaloniki, and Helsinki. Two others, Lisbon and Oulu, have been added here[4]. The cases represent lessons learnt from managing a transformation

[4] All six cases are included in FIREBALL Deliverable D2.1: Landscape and Roadmap of Future Internet and Smart Cities, April 2012. The four case versions included in the Journal of Knowledge Economy have been reviewed, shortened and edited. This White Paper contains short summaries of the cases.

towards smarter, more intelligent cities. The cases offer valuable understanding about the steps made in cities located in north, south, eastern and western Europe and reveal common challenges that have been addressed and solutions explored, despite the geographical and socio-economic differences of these cities. The cases demonstrate a tendency towards more decentralized and bottom-up approaches to planning and innovation. Innovation ecosystems are evolving through a combination of top down and bottom up initiatives, leading to networking and collaboration among stakeholders, which eventually are extending to real innovation communities. Increasingly, citizens, advanced companies and local governments act as proactive catalysers of innovation, shaping cities as "agents of change". They also outline components of a strategic thinking about smart cities and the long term perspective which has to be adopted, the involvement of multiple actors that operate within a city, and the different solutions needed for the subsystems of a city.

3.2 Barcelona: From traditional agglomeration to metropolis

In 2009, Barcelona came fourth in the ranking of Europe's best cities for locating business [Cushman and Wakefield 2009]. Its extensive industrial foundation and entrepreneurial structure helped Barcelona to become a knowledge-intensive economy. Knowledge is used as an engine for economic growth to support production and the generation of talent with more than 400 research centres. Barcelona is pioneering the Smart City concept with various initiatives like the 22@Barcelona district.

Fig. 3-1. Barcelona Smart City Campus at 22@Barcelona

Barcelona has set up explicit urban policies and reforms aiming to lead towards becoming a Smart City. Barcelona Smart City strategy aims to provide an environment for generating smart ideas in an open environment through fostering clusters and Open Data or developing proper living labs while directly involving citizens in the co-creation process of products or services. A distinguishing characteristic of Barcelona's smart city approach since the 1990's is its approach to urban governance, which includes a close collaboration between politicians and companies as well as academic institutions and residents, together developing smart projects. The general objective is to use ICT for smart services in order to transform the business process of public administration both internally and externally to be more accessible, effective and transparent. The main driver of the Barcelona Smart City is the fostering of competitiveness of the city. Other drivers are to promote innovation, create new channels of communication, facilitate access to information both locally and internationally and improve the efficiency of public services. Barcelona's smart city knowledge

economy is built with an industrial network and clusters creating a relationship space, social network between companies, institutions and city hall and citizens. This interaction of the citizens with this area and companies creates a knowledge society.

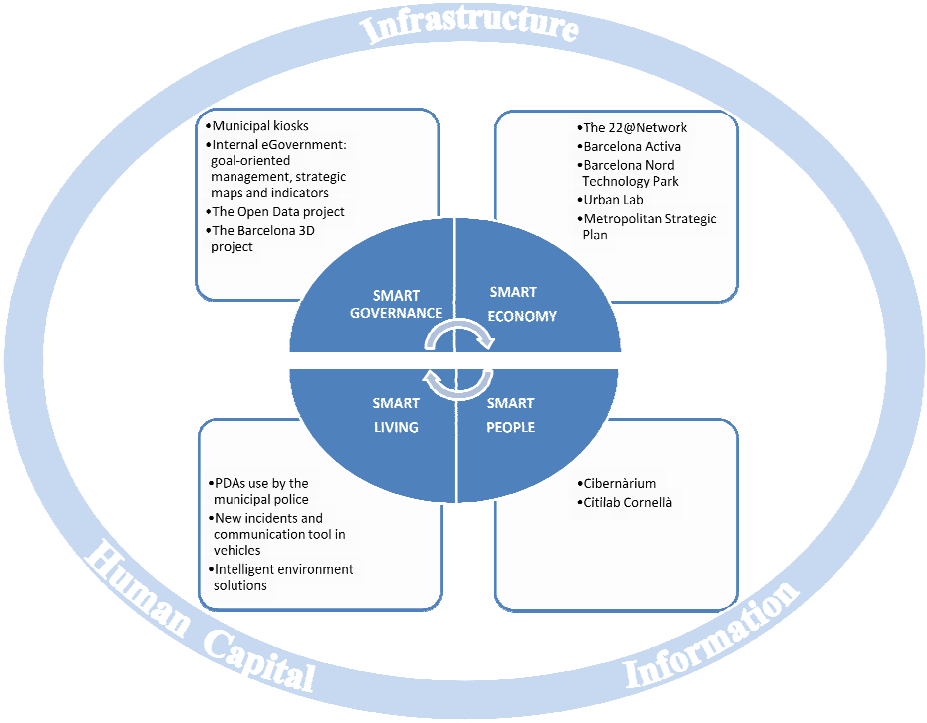

Figure 3-2. The main assets of Barcelona Smart City initiative Model[5]

The main assets of Barcelona Smart City Model (Figure 3-2) enable the launch of major initiatives, namely: Smart Governance, Smart Economy, Smart Living and Smart People. Smart Governance is based on Open Data with information kiosks and maps providing a better access to government information. Barcelona Smart Economy is based on the creation of innovation clusters, and a triple helix concept with interacting companies, faculties and citizens for fostering innovation. The initiatives under Smart Living are targeting new technology adoptions that are mainly initiated by municipal police and tool developments for public transport. Finally, Smart People mainly involves training programs for digital literacy of the Barcelona City hall. To support these initiatives Barcelona use existing or new infrastructures; the 22@Barcelona innovation district; Corporate Fibre Optical Network; Wi-Fi mesh network; Sensors network and Public Wi-Fi network.

Barcelona Smart City model foundations lay on three pillars, namely ubiquitous infrastructures, information and human capital. The goal is to provide citizens and enterprises with a powerful platform connecting city elements for an effortlessly interaction with each other and with their administration through electronic means. Optical fibre networks cover the city acting as a backbone to the installation of sensors for the development of intelligent solutions in cities.

Information coming from daily activity in the city is an invaluable asset that needs to be collected and interpreted, creating a Smart City information space that acts as the basis to deliver smart tailored services and better city management. There are two main information sources: 1. information

[5] Generated from: 1) Ajuntament de Barcelona: 22@Barcelona, the innovation ddisrict (2010), 2) J. Battle (2010) Barcelona Smart City: Paving de Way. Ajuntament de Barcelona; 3) J. Battle, A. Majo, J.L. Ventura, M. Vila, I. Ponti (2011): Interviews, Barcelona City Council.

coming from the city that involves sensors and city elements and Open Data (public sector information); and 2. information coming from the citizens as digital footprint, social media and Crowd Sourcing.

The implementation of the Smart City is not only a concern of public administration as it should involve the human capital: population, innovation centres, companies and entrepreneurs. Faculties and society are knowledge producers, while companies and entrepreneurs generate new business opportunities. Cooperation among these actors seems to be the key for talent development.

Main Components of the Smart City Strategy of Barcelona

Barcelona Smart City concept is used as a strategic tool to encompass modern urban production factors in a common framework and foster competitiveness of the city. The main Barcelona Smart City Model components are:

- **Smart Districts:** The 22@Barcelona district supports the formation of urban research and facilitates a new working space among the Barcelona city hall, companies and institutes. This space is intended to foster research activities about the smart management of the urban space and e-services. The main objective is to sustain an area for the collaboration with companies and institutes for new product developments while improving the urban management. It also creates a space of personal relationships. It constructs an affiliation sensation to the community of 22@Barcelona and this also encourages feelings such as pride to live and work in 22@Barcelona district.
- **Living Labs initiatives:** 22@Urban Lab is another component for new infrastructures and services, inspiring companies to test and develop innovative solutions as products or services in any field: sensorization, urban planning, mobility, education. Living Labs are used as tools and processes for the creation of user innovation cooperatively in real life environments. It is employed for learning, conducting tests and research for the implementation of new technologies and services of organizations in large-scale real-life environments.
- **Infrastructures:** The traditional infrastructures are redesigned to ease the integration of ICT at all levels. This can take place either as a minor road renewal or a whole transformation of a major district such as 22@Barcelona or Sagrera for a model of territory adaption to the new needs. This major transformation involves infrastructures such as companies, institutions, specific spaces, universities, technological centres, incubators, residences, dissemination, entrepreneurs, and other services. The backbone of the smart city involves special public property infrastructure plans. This involves Wi-Fi and optic fibre, a new mobility plan, new heating and cooling systems, new energy networks and underground galleries.
- **New Services for the citizen:** A corporate optical fibre network to connect the main municipal buildings; a Wi-Fi mesh network to provide wireless connection to those municipal services and employees working at street level; sensors networks to manage a multivendor, multipurpose sensors network configured to be used by several providers; and a Public Wi-Fi network. Services created by citizens for the citizens, including also the professional arena, boosting cooperation between the several elements of civil life are grouped under Citizen to Citizen services. These services are based on public Open Data, representing the real social innovation and the real openness of a city.
- **Open Data:** These data involve territory, population, management and procedure indicators, urban environment and documental data. It is society's right to use this data, whether to brief themselves or for creating new services, increasing social value and perhaps also commercial value.

Benefits and Challenges

A detailed and clear assessment of the benefits and costs of Barcelona's smart city strategy is not available. However some observations can be made. The 22@Barcelona District, city hall created new employment opportunities, moved universities to the area, provided social housing, urbanized green areas and provided more efficient public services. The city has created more than 4.000 units of new housing with 25% less rental, 55,000 jobs with over 1500 new companies, and new institutions, mainly in information and communication technologies and media industries. It has 10 universities and 12 R&D centres.

Private organizations gained from the use of leading-edge infrastructures, higher density of collaboration and networking. For instance, through the 22@Urban Lab, new products and patents were generated from commercial products that have been tested and validated at least in one city. This assures the viability of their solutions in a real environment while fostering innovation. Hence the Smart City model provides a higher rate of innovation, creativity and cohesion for both parties.

Barcelona is also facing a number of challenges and problems. A challenge at infrastructure level is to provide the appropriate infrastructure, deployment and management of wireless networks. A more fundamental challenge is the creation of triple helix networks, clusters and collaborations. In that respect, Leon (2008) highlights five major challenges: 1. Skilled human capital level was not enough to satisfy the needs of industry clusters; 2. Level of local entrepreneurship was lower compared to any other country in Europe; 3. Venture capital funding was not sufficient to attract firms and finance start ups; 4. The number of large firms to lead innovation was low; and 5. In the business context, global connectivity of Barcelona was poorer compared to other European cities.

Also, it is observed a top-down approach in leadership leading to difficulties about local engagement and collaboration across departments sometimes. The planning and use of new products and services should be well integrated with the social and economic programs of the city in order to provide a real test environment. As cross-departmental cooperation and clear definition of roles and responsibilities is quite challenging, intermediary organizations were used for facilitating the cooperation.

Another issue is in coping with the economic situation in Spain, which affects public funding and projects. A major challenge for the years to come is to provide effective governance actions in the case of budget restrictions while sustaining urban growth with continuous development.

In the near future, Barcelona will need to continue to proactively engage and collaborate with public and private organizations as well as with knowledge institutions. Other cities may learn from Barcelona how to base their Smart City models on three main pillars infrastructure, human capital and information. For Barcelona, main obstacles are the management of the initiative, providing necessary infrastructures and creation of collaborative networks. Both public and private sectors benefited from this initiative in terms of enhanced public services, innovation, business developments and a more collaborative system. As the main outputs of the Smart City model, smart services have been successfully implemented to boost cooperation, innovation and development. To sustain an effective urban management system, intelligent network technologies are required to drive economic growth, to support a sustainable green city and provide a better quality of public services.

Table 3-1 summarizes the prospects for implementing Barcelona as a smart city in terms of a SWOT analysis.

Strengths	Opportunities
• Attractiveness for industry, tourism, cultural heritage • Knowledge intensive economy; cluster • Urban planning and regeneration history • Major initiatives e.g. smart districts (22@Barcelona), living labs, ubiquitous infrastructures • Leading role of City Hall	• Potential to attract companies • Services to enhance local entrepreneurship and innovation
Weaknesses	**Threats**
• Mostly top down orientation • Lacking coordination among government departments • Human capital level • Local entrepreneurship level	• Economic situation, affecting public funding • Existing projects may be affected by governmental change

Table 3-1: Barcelona Smart City strategy implementation - SWOT

3.3 Thessaloniki: adopting the paradigm of "intelligent city" by promoting smart districts

The case of Thessaloniki highlights how a city is adopting the new paradigm of intelligent cities and how the deployment of broadband networks, smart urban spaces, web-based applications, and e-services is helping every district of the city to address its particular objectives of competitiveness and sustainable development. It describes an evolutionary course from digital to intelligent and smart city. The digital life of cities starts at the hyper space, but it soon becomes part of the social life and the physical environment of cities, empowering people and advancing citizen's capabilities by collaborative, collective, and embedded intelligence. An irreversible stream is driving the city from digital applications to smart ecosystems and intelligent places.

The knowledge economy of Thessaloniki is developing via two parallel processes: on the one hand by setting up innovation clusters and technology districts, such as the Technology Park of the Centre for Research and Technology, the Technopolis ICT business park, the Thermi and i4G incubators, the Alexander Innovation Zone, and on the other hand by deployment of broadband networks and web-based services for business, government, and citizens sustaining a new economy around the ICT sector. These two processes are not coordinated, the first being supported by public Research and Technology policy, while the second is progressing thanks to private investments being made by large telecommunication companies, Internet service providers (ISPs), and ICT companies. The process towards "intelligent Thessaloniki" highlights how these two fundamental processes of knowledge development complement each other, and how broadband networks, e-services, and smart environments sustain the main production and innovation ecosystems of the city.

Broadband Networks

Broadband access in Thessaloniki is provided by a number of private operators, such as OTE, Vivodi, Telecom, "Tellas, Hellas On Line" (HOL) and Forthnet, with ADSL being the main standard. High-speed VDSL is also offered. Most Internet providers use OTE's Bit Stream Network, which is the most extensive privately owned fibre optic network. ISPs lease ADSL connections to offer online services but they do not have access to OTE's network infrastructure. Additional broadband connectivity is offered by the GRNET fibre optic network that interconnects the city's universities, technical and research institutes to a wider academic and research institution's network. 3G coverage is very important doubling the Internet penetration. It is offered by three mobile telecommunications service providers in Thessaloniki. Wireless broadband is offered by many public organisations covering various city districts. These networks have been developed by local authorities, the Aristotle University, the Expo, the Port area, and other public or semi-public organisations. Non-profit initiatives operating on a community / collaborative basis also offer free wireless broadband connections using cheap wireless technology for creating an open metropolitan network.

Bottom-up Creation of Applications and e-Services

Web applications and e-services are running on broadband networks and concern the city's activities, its digital presence and functioning. Most of these applications come from bottom-up initiatives created out of the interest of their developers. However, seen as a whole they create a rich layer of digital services which is emerging from dispersed individual actions. Web based applications address the city as a whole, in contrast to applications related to its constituent objects, and deal with the representation of the city, the functioning of city sectors and districts, content aggregation by citizens, the provision of administration and social services, location-based services, management of city infrastructure and utilities (transport, power, water, broadband), decision making, city planning and consultation. Best known e-services are those related to administration offered by public authorities, mobility and transport services, and local e-commerce, advertisement and marketing. The most technologically-advanced ones and best integrated into the physical space of Thessaloniki are those relating to mobility (public transport, fleet management, route planner, intelligent road monitoring).

Fig. 3-3. Districts of Intelligent Thessaloniki: Port area, CBD, University campus, Eastern technology district

Combining Bottom-up Initiatives and Top Down Planning: Toward Intelligent Thessaloniki

These bottom-up initiatives are coupled with top-down planning for turning smart the main productive districts of the city. "Intelligent Thessaloniki" is a strategy for deploying ICTs and web-based services in metropolitan Thessaloniki with the clear objective of strengthening the innovation ecosystems of the city and the new growth sectors of transport, commerce, education, and high-tech industry. This planning effort is blending ICTs and innovation at the city district level, with the aim to create smart city districts endowed with applications and e-services adapted to each city district that enable the mobilisation of collective intelligence and crowdsourcing for learning, innovation, digital marketing, and performance benchmarking. "Intelligent Thessaloniki" is focusing on the most important districts of innovation and entrepreneurship within Thessaloniki. Applications and e-services vary from one city district the other. In the *Port area* and surrounding cluster, smart

environments are focusing on competitiveness of the post vis-à-vis other ports, lowering operating costs, improving the quality of service, integrating freight transactions, and monitoring and benchmarking the operations of the Port. In the *Central Business District*, digital spaces are seeking to increase the number of visitors and the competitiveness of the CBD, to stop ground being lost to peripheral malls; to facilitate mobility and parking, as well as environmental monitoring and alerts. At the *University campus*, smart environments are targeting on the dissemination of research, the opening up of the University to the local productive fabric of the city, and the strengthening of collaboration with enterprises. In the *Eastern technology district*, smart environments are expected to facilitate the promotion of premises and to attract tenants, to provide online technology services, and to support new business incubation.

Following this concept, a smart commercial district is under development in the central commercial district of Thermi in Eastern Thessaloniki. It aims at addressing competition from large shopping malls and sustains the local marketplace which is composed by traditional commercial and service SMEs. The smart district is build upon a interlinked group of web-based applications, apps for smart phones, and sensor networks, including:

- **A smart marketplace** managed by the local shopping community, combining a business directory of local businesses and professionals on the city map; a virtual marketplace where local storekeepers are able to present their stores using text, photos and video; a coupon site containing promotional codes from local retailers and professionals, offering discounts to specific products and services; a virtual supermarket based on open data enabling consumers to compare goods from local stores and create best price baskets of goods; a review engine that assists customers in gathering local shopping information, posting reviews and opinions.
- **3-D visualisation and promotion of local recreation facilities** on an interactive map of the city, which is enhanced by the superposition of public points of interest, such as public buildings, monuments, museums, parks, recreational facilities.
- **Smart parking alert and displays** offering real-time information about the number of places available in various city parking.
- **Air pollution monitoring and alert** based on a Wi-Fi sensor network providing real-time information about air condition, CO2, microparticles and other pollutants.
- **Environmental reporting to municipality services** enabling citizens to report local problems and incidents such as discarded trash, burned lighting, broken tiles on sidewalks, illegal advertising boards, propose solutions for improvement, and being informed about the process followed by the city authorities.

The development of applications follows cycles of innovation, monitoring and evaluation. Stakeholders and lead-users are invited to assess solutions and give opinions for improvement. After each innovation cycle, results are evaluated thoroughly and the conclusions have impact on solutions of the next innovation cycle. The assessment is based on indicators related to activation of stakeholders, activation of (lead) users, ICT services offered, data models and information flows, and business models for sustainability.

"Intelligent Thessaloniki" is implemented in stages and on a per district basis through open calls for drafting and implementing detailed plans for the Port area, the Central Business District, and the other districts. However, the current financial crisis poses major obstacles to financing because all public funds are directed to the servicing of debt. The projects are progressing primarily through initiatives of the administration of each district, rather than by central planning as it was foreseen initially.

Impact

The survey we conducted about broadband development, web-applications and e-services in Thessaloniki reveals mainly qualitative aspects of the impact of digital Thessaloniki on city growth and citizens well-being. Impact can be defined by a series of improvements to various city subsystems, infrastructures, and activities: the ability to react quicker in the case of an accident on the ring road; the option to find the best route for travelling from one place to another; the ability make a transaction online; the option to pay a parking ticket online; the ability to make a request to a government department online or inform authorities about an accident; the chance to learn about cultural events in the city or find a hotel or a restaurant; the ability to learn the city better, share a bike; buy something at a great discount, and so on and so forth. These fragmented outcomes are inherent in the way systems and applications have been development via bottom-up, decentralised actions, without a comprehensive digital master plan.

Governance Challenges

The development of broadband networks, digital applications, and smart districts in Thessaloniki provides some insights about the governance of the new digital - social - physical spatiality of cities. Similar processes are taking place in many cities all over the world combining individual bottom-up initiatives and targeted state-led top-down planning. The twin processes of city development - from below and above - are somehow replicated in the creation of the urban digital space and its integration with pre-existing social and physical spatialities. Major challenges to be addressed concern the characteristics of broadband networks balancing development costs and benefits, the digital skills gap and the ability of citizens and companies to master web-technologies and offer solutions over the net, the creativity gap with living Lab methodologies, social experiments, crowdsourcing, and open city platforms, and the entrepreneurship gap with successful business models for smart environments sustainability.

Table 3-2 summarizes the prospects for implementing Thessaloniki as a smart city in terms of a SWOT analysis.

Strengths	Opportunities
• City development strategy with respect to knowledge-intensive clusters • Bottom-up deployment of broadband networks and web-based application and e-services • Community not-for-profit initiatives for open broadband over the public space • Both bottom up (initiatives on infrastructure and applications) and top down (planning for smart districts) • Alignment of smart city strategy to cluster-based development strategy	• Strengthening competitiveness of local economic clusters by user-driven innovations initiatives • Opening up city clusters (expo, port, campus, technology district) to global cooperation • Exploiting infrastructure and service opportunities for growth, wellbeing, entrepreneurship, innovation • Creating opportunities for the local ICT sector and young entrepreneurship in ICT • Development of applications and solutions for saving in energy and other city utilities • Introducing participatory city planning and city governance
Weaknesses	**Threats**
• Document impacts and benefits of the Intelligent Thessaloniki strategy • Align citizen / SME needs and infrastructures / services capabilities • A few only policies for bridging the digital gap and the development of Internet-based entrepreneurship • Low level of Internet use in other professional activities than e-commerce	• Economic crisis severely limits public funding of initiatives • Vulnerable business models for the long term sustainability of public sector initiatives • Low level of private investment in R&D related to future Internet technologies and solutions • Weak institutional environment for technology and innovation, especially user-driven innovation.

Table 3-2: Thessaloniki Smart City strategy implementation – SWOT

3.4 Manchester: Urban regeneration through digital development

Innovation in Regeneration

The Manchester case study highlights the role of digital development strategies and creating a knowledge economy for boosting urban regeneration. Manchester has gradually evolved towards the concept of smart cities. In the 80s, Manchester City Council embarked on a radical new approach to regeneration. A new Economic Development Department was established with a proactive approach to economic restructuring and social change towards Innovation in regeneration. Three thematic priorities were defined at that time, namely: set the focus on area and neighbourhood based working; develop a 'creative city' strategy demonstrating the economic importance of the 'arts and cultural industries'; encourage innovation through the development of Manchester Science Park and the recognition that ICT could play a significant role in creating new infrastructures and services and, consequently, future economic growth.

These three themes were at the heart of the new Economic Development Strategy for the City and remain at the core of Manchester's neighbourhood regeneration strategy twenty years later for generating sustainable economic growth and reducing dependency through tackling unemployment, inequalities and social exclusion. In 2011 the launch of the EU's Digital Agenda for Europe [2] provided a high level strategic framework for supporting the development of policies and actions to maximise the benefit of the Digital Revolution for all. As a consequence, cities and regions prepared "Local Digital Agendas" to set out their aspirations for change, while at the same time focusing on practical action and initiatives for delivering that change supported by digital technologies and a "user driven open innovation approach".

Manchester reviewed its own Digital Strategy and digital development priorities while focusing on three main issues, namely: *digital inclusion* for tackling the digital divide[6]; *digital industries* for building on Manchester's strengths in order to overcome the lack of business finance to support new investment and start-ups and the need for better access to skills and pathways to employment in the sector; *digital innovation* for generating investment for innovation and new infrastructures and working with the research community on Future Internet development to support Manchester as a 'Smart City' in areas such as smart energy, cloud computing and very high speed NGA[7] digital infrastructures (fibre and wireless), networks and services.

The Manchester Digital Strategy mainly addresses the concept of "Smart Citizens in Smart Cities", using digital technologies to promote community engagement, capacity building and social capital. To use the four level social capital model, namely: creating a common vision and a sense of belonging for all communities through imaginative uses of digital technologies to help to transform lives; ensuring that diversity is appreciated and positively rewarded through improved accessibility of digital technologies to support social networking; engaging people from different backgrounds through the use of digital technologies which enables them to have similar life chances; encouraging strong and positive relationships to be developed between people from different backgrounds in the workplace, in education and within neighbourhoods by using digital technologies to break down barriers and promote social cohesion.

Today, Manchester Digital Development Agency (MDDA) continues to combine innovation through new initiatives, including the Manchester Living Lab, so that it can be the way by which people and businesses can easily connect and collaborate while providing access for ensuring that all local residents, plus those who come to Manchester to work, study or visit, have the most accessible and

[6] Over 50% of households excluded communities no longer having or using copper based landlines
[7] Next Generation Access

affordable ways to use the Internet through local access centres, NGA networks and wireless connectivity; generating Business opportunities for enabling existing digital businesses to safeguard existing jobs and create new ones, developing pathways into employment through training and skills programmes, including apprenticeships, supporting new start-ups and social enterprises opportunities and promoting new trading opportunities and promotional activities; Capacity building for using digital technologies to build social capital and to support community engagement so that there is real local benefit generated by innovation, which, in turn, increases digital inclusion, provides access to skills and jobs and improves the quality of life through green digital and open data initiatives, working in collaboration with local partners such as the Manchester Digital Lab (MadLab).

Smart City and Living Lab Initiatives

A number of examples of MDDA project development in these areas include: 'Fibre to the People' – the Manchester Living Lab pilot project that started to roll out next generation access digital infrastructure; Manchester 'Internet Hub' – ensuring that Manchester can develop its 'Internet Exchange' capacity to be a globally competitive 'Internet Hub' based on enhancing connectivity across the city; Low Carbon Open Data Network – extending the wireless connectivity around the Corridor area to collect real-time environmental data using low-cost, low-power sensing equipment and providing open access to the data through a range of online services; Smart Innovation & People – a European project connecting up digitally supported community engagement initiatives in Manchester and four other European cities working in partnership with Peoples Voice Media's 'community reporters' project and the University of Manchester; Green Digital Charter – a European wide initiative to reduce the environmental impact of digital technologies and to develop innovative 'smart energy' projects, such as Internet based interactive smart meters, that can improve energy efficiency and get people involved in new and imaginative ways of reducing their personal and collective carbon footprints; Digital and Creative Skills – bringing together businesses in the digital and creative sectors, including through Manchester Digital, education and training providers, community networks and other major employers to develop more innovative ways for people to gain skills that can help them get access to jobs, set up their own businesses and get access to advanced learning opportunities through non-traditional routes, including apprenticeships.

Manchester ambition is to become a Digital City Test-Bed with an open innovation Living Lab for creating Future Internet next generation services and applications, such as developing more efficient public services - NGA is key to enabling city service providers to maximise the ability for citizens to self-serve and to provide efficient access to expensive specialist resources, such as expert medical care, using innovative new services such as telemedicine; exchanging knowledge and expertise - cities are ideally placed to mobilise and aggregate demand for NGA services for the Future Internet 'Smart City' and to provide the strong leadership required to make this happen. The 'Core Cities' network is currently working on an initiative to develop closer engagement between City Leaders, Government, Communications Service Providers and the Internet industry as a whole.

The Manchester City Region NGA initiatives are being developed in partnership by MDDA, which is part of Manchester City Council, and the Commission for the New Economy, working on behalf of the Association of Greater Manchester Authorities (AGMA) in the context of the City Region Pilot and the proposed 'Combined Authority'.

There are currently linked initiatives being developed:

- The Corridor 'Living Lab' NGA pilot project, aiming to connect 500 businesses and 1,000 residential users through a FTTP network. This will be an access network testbed enabling new business to business, business to consumer and community based applications and services to be developed as well as innovation in public service delivery in areas such as telecare/e-health, energy efficiency/smart energy, e-learning, smart mobility and flexible working;

- The Manchester City Region NGA Initiative, which is currently undertaking a feasibility study on the scope for market investment in new and innovative models of NGA delivery which would harness the advantages of the core network being developed in Manchester and extend this using all possible routes (e.g. Metrolink and other transport corridors together with Public Service Network development) across the whole of Greater Manchester, including those in the 'final third' rural communities and those in inner urban excluded from access by virtue of financial and other social barriers.

This covers not only existing projects being undertaken by City through the MDDA but also 'bottom up' grass roots initiatives being developed by local partners in collaboration with the MDDA. The 'Roadmap' aims to map existing work going on in the city region, which is relevant to the 'Smart Cities' agenda, and to identify how this fits into the future vision, the challenges and gaps which exist and the future solutions and innovation needs in terms of realising the targets and aspirations of the Manchester city region. The 'Roadmap' is seen as a first stage in the process of developing the Local Digital Agenda for Manchester and the Green Paper is in place to stimulate discussion and consultations so that these responses can be used to validate proposals for future work and that this will be able to inform the production and implementation of the Local Digital Agenda for Manchester. Some of the policies, as outlined above, are in place to facilitate and support the transformation process of Manchester into a 'Smart City', but there is still much to be done to ensure that the opportunities that the Future Internet can provide to a city region such as Manchester are fully exploited.

It seems that Manchester has developed some interesting principles underlying their smart city strategy: neighbourhood regeneration as a starting point, collaborations through living labs, exemplar projects, focus on people in the heart of the agenda, and aiming for inclusion and sustainability. However it remains to be seen how these principles work out in practice. Table 3-3 below summarizes the strengths, weaknesses, opportunities and threats as regarding the implementation of Manchester's smart city strategy.

Strengths	Opportunities
• Strong knowledge infrastructure and science-innovation landscape • Pro-active policy focus on urban regeneration and economic development strategy • Broadband infrastructure deployment, wider range of innovation projects, and adoption of living labs approach	• Use of digital technologies for stimulating urban regeneration and entrepreneurship and to retain competitive digital advantage • Supporting SMEs with leading edge connectivity according to their needs
Weaknesses	**Threats**
• Local networks insufficient to facilitate spread of innovation • Commitment of partners • Lacking monitoring and evaluation of impacts of smart city policies • Realisation of concrete projects connecting with needs of citizens and entrepreneurs	• Economic recession, reductions in staff, budget • Difficulty to create sustainable partnerships

Table 3-3: Manchester Smart City strategy implementation - SWOT

There are a number of specific lessons learnt from Manchester's experience:

- The need to develop digitally enabled services that are based on the social, cultural and economic needs of the neighbourhoods, requiring the capture of user needs and involving users in the design and delivery of new services, the start of the co-production process;
- Stakeholders in the project, especially the public sector, need to demonstrate a long term commitment to community engagement and capacity building, and invest as much in the development of people's skills, confidence and aspirations as in the technology being deployed;

- The need to have an ongoing evaluation strategy that not only has the ability to identify weaknesses, and even failures, but also has the role of communicating these results directly into the strategic decision making process so that the project can accordingly adapt and evolve;
- The importance of developing real exemplars that push the boundaries of what people know and their expectations, so that people's imaginations are stimulated and horizons widened while this is communicated with all the power that Future Internet enabled communications can bring with the most effective social media and social networking;
- The potential for generating added value from innovation and new investment into the area while at the same time focusing existing investment within those locations and sectors that are most capable of delivering growth, in order to respond to the ongoing structural shifts in the economy towards knowledge industries, including Future Internet enabled services.

3.5 Helsinki: towards a smart city cluster built upon user empowered innovation

Helsinki Smart City – Region

As the leading national expertise cluster, the Helsinki Region remains the strategic core of Finland's international competitiveness. Helsinki region is the economic heart of the Small and Open Economy (SMOPEC) of Finland. 'Helsinki Region' is both a fairly loose cross-municipal organization and a vaguely defined area surrounding the capital region, consisting of the City of Helsinki and 10-15 municipalities around it. Helsinki Region has no strategic planning instruments and decision-making bodies as such. However, collaborative arrangements for water management and public transport and various informal networks are grounds for active co-operation. For the metropolitan region to become and function like an effective 'Smart City' a change towards increased collaboration between the municipalities is needed. Helsinki, as a developing Smart City working to promote a Smart Region, does not endorse limiting smart solutions to its municipal boundaries, or to organizations that serve a single municipality. Removing boundaries between bureaucratic organizations is necessary within and across a competitive and agile smart region of the future. For the Helsinki Region to act effectively towards smart services it must provide platforms for innovation that are open to all municipal and regional parties with an interest in developing new products and services. The competition for applications cases shortly discussed below forms evidence of this (cross-municipal) collaboration in setting up an innovation platform around open data aiming at smart services for citizens.

As indicated, collaboration is of crucial interest. The first innovation strategy for the Helsinki Region shows the way forward for collaboration that will more efficiently harness the huge innovation potential of the metropolitan area. The future competitive strength of the Helsinki Region and its appeal as a strategic partner for the world's other leading knowledge hubs will depend on the Region's record of effective collaboration. In terms of Porter's concept of cluster, Helsinki region forms a strong innovation oriented cluster around mobile technology, based on favourable factor determinants such as high quality research and education institutes, a continuous demand for change and innovative services, a highly competitive business environment, and at the same time a strong innovation driven networks of businesses and with governmental actors.

Living Labs

The prominent role of user driven and open innovation (living labs) underlines the strength of the cluster. Actively supported by local and regional government, as well as through governmental funding for research, development and innovation projects, Living Labs have been established in and around Helsinki Region (e.g. Helsinki Living Lab and Arabianranta Living Lab). Their functions are diverse, but all are basing their activities on the principles of User Driven Innovation. There is a strong tradition of Living Lab research in Finland and various types of organizations – Universities,

city or region owned development agencies (Forum Virium), companies and SMEs have established Living Labs in the Helsinki Region area. The municipalities use Living Labs for economic development and societal activation in energy issues, or service provision in health care of the elderly, preventive care, or urban living. Several Universities of applied science conduct research in Living Labs at the edge of science and practice. Companies such as NOKIA, or Philips, use Living Labs as user-centered hubs for ideation and product development and national research institutions use Living Labs as platforms for innovation. These living labs focus on bringing users with their knowledge, ideas, and experiences together with the developers of new services and products to increase the quality and usability of the services and products created. Collaboration with local small and medium sized companies is actively sought and managed, while entrepreneurship is enhanced at service and design 'factories' through new collaboration models at the newly merged Aalto University.

While the role of living labs is only a partial aspect of Helsinki Smart City it has a wide influence because of its emphasis on openness, user engagement and co-creation. Within the Helsinki cluster environment it provides a powerful glue between all the elements of a strong innovation system.

Mobile Application Cluster

For the Helsinki Smart City strategy the emergence of a mobile application cluster is a benefit and the resulting competition within the cluster is equally essential. The proximity of the cluster members, both geographical and cultural, supports the constant drive to innovate in order to grow. This gives a push to development of innovative ideas for the Smart City. The user and citizen's participation and demand provide a pull. By becoming a centre of innovative and competitive firms a cluster attracts new firms to the area, creating economic growth. Within the Helsinki Region, this competitive-collaborative process is ongoing within IT, media, services, and particularly in the sector of mobile application development.

The City of Helsinki has stimulated the development of a Mobile Application Cluster through organizing competitions for innovative applications. The Smart City services that are developed in competitions benefit both the Mobile Application Cluster and the citizens. The function of the competition mechanism to encourage the development of new mobile applications utilizing Open Data is described with examples from the Helsinki Region. Porter's diamond model of determinants of national competitive advantage is used as a framework to describe the forces driving the ongoing developments towards the Mobile Application Cluster. In particular the paper explores the interaction between the cluster determinants of Porter's model with regard to the externalities made by the linkages between the parties in the emerging cluster. In the two competitions for Open Data applications that the paper discusses innovation is supported by a policy-like instrument: an urban competition on open data, which is driven forward through the Living Labs approach to innovation. The two competitions launched in the Helsinki Region are aimed at developing mobile applications by utilizing open data. This case study shows how a Living Lab functions as an innovation intermediary where the competitions are utilized in developing a Smart City.

Helsinki Region Policies

As the leading national expertise cluster, the Helsinki Region remains the strategic core of Finland's international competitiveness. High educational standards, a firm grounding in science and technology and a long track record of cooperation between the private and public sectors have laid the foundations for developing innovative products and services in the Helsinki Region. As open environments for development, learning and interaction, development platforms reinforce strategically important areas of expertise and competitiveness in the Helsinki Region. Designing, implementing and developing such platforms is an excellent objective for the common business development policy of the cities.

Apart from the well-organised platform and co-ordination among the stakeholders, innovative funding solutions are needed to boost both RDI and innovation commercialisation. Policy instruments in place include Pre-commercial procurement (PreCo) and Innovative City® as Innovative funding solutions boosting innovation in the Helsinki region. The Innovative City® Program is an urban innovation tool owned by the City of Helsinki and Aalto University and was launched by the City of Helsinki and the Helsinki University of Technology in 2001. Today, this cooperation continues and develops with Aalto University from 2011 onwards.

Table 3-4 summarizes the prospects for smart city strategy of Helsinki in terms of a SWOT. Smart Cities make use of the possibilities created by Internet and Future Internet technology. The Helsinki Region seems to be well positioned as a model of a Smart City for the push it gives to development of new technologies within a multi-leveled infrastructure and towards the creation of new business sectors. Many elements needed to create, develop, test and market new ideas and new technologies, are present. However there are also some weaknesses and threats to be mentioned, such as the lack of diversity in technology base, and the peripheral position of Helsinki.

Strengths	Opportunities
• Strong, mobile innovation oriented cluster • Strong level of collaboration government – business - universities • Prominent role of user driven, open innovation • Innovative policy instruments	• Strong innovation driven collaborative networks • Push for creation of new business sectors • Emerging entrepreneurial ecosystem
Weaknesses	**Threats**
• Strong ICT sector but lack of diversity • Limited human capital base • Peripheral position in Europe • Small scale	• International competition • Dependency on mobile technology, lack of diversity

Table 3-4: Helsinki Smart City strategy – SWOT

3.6 Lisbon: towards an international hub and sustainable city

Lisbon's ambition as a smart city is to improve the city's liveliness and quality of life, namely through the active involvement of citizens in the city's governance model. Lisbon aims to become an international hub for world scale companies, benefiting from the bridge Lisbon represents between Europe, Africa and America. The city strives becoming a pole of creativity and innovation with a prospering atmosphere for entrepreneurs, and incubator for new ideas and business models.

This strategy is set to facilitate creativity, providing citizens, small enterprises, start-ups and civil organizations the tools needed to create, to innovate, to enable social innovation, centring the citizen as a co-producer and partner of the City ("Lisbon Smart City", www.lisboaparticipa.pt). The strategy defined for Lisbon's Smart City is based on three pillars:

- **Building spaces**: Lisbon Municipality sets as its role to provide open innovation spaces to the public, namely initiatives such as Co-Working spaces and FabLabs. These spaces intend to foster creativity, benefiting from the co-existence of competences and joint efforts toward a common goal.

- **Fostering entrepreneurship**: Lisbon positions itself as a privilege city for the launching of new business projects, namely in the creative industries, information and communication technologies and several other areas. Benefiting from different competences and promoting interaction platforms between cooperating stakeholders that can be essential in the successful launch of new enterprises. Examples of such initiatives were the TEDx Lisboa, the Silicon Valley in Lisbon, Ignite, Lisbon Talks, among others. Additionally, a strong effort has been put through creating business incubators for start-ups as well as joining assets and promoting synergies

between actors, motivating the market's creativeness to deploy new services and functionalities, creating added value business lines that can further grow to new start ups.

- **Useful tools**: Create useful tools for the city; improving its quality of life is the challenge and the basis for making available a wide variety of data sets so that citizens can co-create new, economical valid projects for the city. This goal is presently being undertaken with the Open Data Lx project where sets of data, from information regarding the city's services to data regarding administrative processes, are already available to the citizen.

Lisbon's Municipality model towards Lisbon as a Smart City bases itself on the principle that citizens, institutions, companies and public services are to work as partners in the deployment of innovative services and products at the city scale. Of key importance is entrepreneurship, enhancing the city's capacity to attract investors and promote the nurturing of new ideas and business models; urban management, improving the city's management structure, focused on the optimization of resources and smarter use of infra-structures and citizens participation, inviting citizen's to actively participate in the city's governance model.

The Municipality should act as a promoter for innovation, development and investigation, setting the grounds for stakeholders to meet and dynamically work towards a greater project, maximizing the use of the available resources and competences. To this end a strategy should be set aiming to pull the citizens to cooperate, not only listening to their voices, but operationalizing the ideas into valid projects, bridging ideas in straight cooperation with the developers. The Municipality's role is to set the necessary conditions for the scientific, economic and social development of the city, providing the adequate environment for startups, placing innovation at the heart of Lisbon's strategy to improve life quality.

The mentioned pillars are an integrated approach to the city's objectives for its near future, to be an international hub for world scale companies, a pole for creativity and innovation, a city with a prospering atmosphere for entrepreneurs, an incubator for new ideas and business models, a dynamic city for exhibitions, events and cultural activities, a center for excellence in investigation and R&D, a sustainable city focused on achieving excellence in the efficient use of its resources and an inclusive city for its citizens, fostering a cooperative environment between the local authorities and the citizen.

Projects are being developed all over the city in all fronts, in a vibrant cooperation between public authorities, private entities, universities and R&D centres, associations and local agencies, centred in enhancing the city's quality of life and involving the citizen as an active voice, involved in the creation and decision process.

The city's goal to foster innovation and nurture new ideas sets on projects developed towards enabling a closer contact between entrepreneurs and business world, fostering social networking and providing the necessary conditions for new ideas and business concepts to flourish in an innovation environment. Examples of such projects are the Fab Lab Lisbon, the Co-working Centres, the Start Up Lisbon and the Lisbon Academy Initiative. Users are at the centre of the innovation process and the Living Lab concept is already a tool, being mostly applied in energy efficiency projects dealing with consumer behaviour. The Participatory Budgeting is an exemplar initiative on how users have a voice on the city's needs and can assess interesting projects for the city's development. On sustainable mobility ICT represents a great asset in developing new solutions and functionalities that facilitate users' adoption of collective transports, soft mobility means and more local friendly technologies as the electric car.

Lisbon is setting its path towards being a true open eco-system where ICT systems have the potential to be adopted at the most different levels of usage and engage public authorities, private entities and the citizens, onto the city's route for becoming a smart, sustainable city. Lisbon's path towards becoming a Smart City is at its very beginning. This fact hinders a thorough analysis of the effective

impact. Nevertheless the achievements of this strategy so far have been very positive with the creation of the Lisbon Start Up, the launch of the Fab Lab initiative and public and private Co-Working centres. At the urban management level the strong effort in the improvement of the public transport system and the collection of real time data regarding energy use in public buildings and services allowed the optimization of infra-structures and the definition of intervention priorities. Finally user's involvement in the city's governance model has been successfully achieved with the Participatory Budgeting Initiative.

The work already developed, namely in the citizens governance area allows to acknowledge positive lessons that are the basis for this strategy's continuous improvement. Citizens are eager to participate, and a proof of this is the increasing participation in the Lisbon Participatory Budgeting initiative that started in 2008 with 1.000 citizens and achieved more than 17.000 participations in 2011. Despite the positive feedbacks a strong effort has to be put into the communication strategy, enabling different actors to interact and represent their role in the society. The Living Lab methodology is already a tool, being mostly applied in energy efficiency projects dealing with consumer behaviour, with positive results and incentives to deploy new projects and address new areas. Entrepreneurial activities, taking advantageous of the assets created are flourishing, especially within the creative industry that already plays an important role in Lisbon's economy and can further be deployed in this sense.

Resources, education, information and confidence are the natural barriers still to overcome. Resources to deploy the mainstream of information and communication technologies applied to the most diverse environments, collecting and integrating data that allows optimizing processes and taking the most out of existing infra-structures. Education is at the heart of a Smart City: "We believe a city to be smart when citizens and visitors have the opportunity to make smarter choices." Education is crucial for citizens to understand the strategy and deploy useful, usable tools. Information, targeted at the different social and age communities and confidence on the common goal, on the overall strategy and on the actors involved.

Table 3-5 summarizes Lisbon's smart city strategy implementation in terms of a SWOT.

Strengths	Opportunities
• Geographic location • Tradition in participative governance process • Political commitment to the smart city concept and projects supported	• Growth opportunities in various sectors e.g. creative industry • Initiatives such as Lisbon Start Up, new business models fostering energy efficiency, citizen engagement in the governance process
Weaknesses	**Threats**
• Bottlenecks and lacking incentives hindering innovation and technology transfer • Human capital resources	• Present economic condition hinder investments in smart city strategies • Confidence on the market actors to acknowledge project synergies and complementarity • Education, vocational training

Table 3-5: Lisbon Smart City strategy implementation - SWOT

3.7 Oulu: a leading wireless R&D hub within the global innovation ecosystem

Since early 90's the City of Oulu has been determined in developing working environments to expedite growth of businesses in the Oulu region. An active role in standardization of wireless and mobile technologies, remarkable investments in public wireless and mobile infrastructure and concrete collaboration with unique PPP programs, have all made Oulu a leading wireless R&D hub within the global innovation ecosystem. Intensive collaboration between companies, public sector and universities, so called "Triple-Helix" has been the base for co-operation for many years. The city of Oulu and Oulu region with its developing infrastructure forms an excellent urban living lab, a system and an environment where real-life user centric innovations flourish.

The City of Oulu has recognized the areas for development identified and presented in the digital agenda as important. For its part, the City of Oulu has worked actively to promote the various preconditions necessary to support a knowledge society. For instance *panOULU,* Oulu's wireless WLAN, has been realized as part of local municipal projects, as has *OmaOulu*, a 'citizen's portal' giving citizens free access to e-services. Within those municipal projects, a clear need has been identified to develop the skills and capacities of both citizens and municipal workers to participate in a knowledge society, in order to improve citizen knowledge of information security issues, helping to avoid security risks related to the use of e-services. Also, the development of skills increases citizens' trust in e-services, resulting in an increase in the use of those services.

In the course of just a few decades, Oulu has become among the most successful cities in northern Europe. In 2015, Oulu aims to be the most developed city in Finland and northern Europe as well; the "city of technology" will evolve into a centre of innovation. In this new strategy, the city states its intention to continue on its present path of strong growth, to multiply its efforts to attract companies based on high competence in different fields to the city, and to promote internationalisation by a significant increase of foreign employees. Oulu intends to gain a clear head start compared to other cities by being number one in terms of service provision and top-level education. For this purpose, Oulu is setting itself demanding challenges and tasks, with the aid of which the top position can be secured. Oulu is also the first city to define creativity and courage as being the most important among the values that guide its operation. Besides creativity and courage, a sense of community and tolerance are emphasised.

Fig. 3-4. (a) UBI-hotspot; (b)UBI-projectors at the City Theatre

The city of Oulu has strongly emphasized the importance of its innovation ecosystem. In 2007, the city created a national level working group to draw up a regeneration proposal for the Oulu innovation ecosystem in order to better meet the challenges of internationalisation of business and innovation. The short term goal was to establish a strategic partnership of Oulu Triple Helix development Alliance, later on called the "Oulu Innovation Alliance", including the City of Oulu, the University of Oulu, the Oulu University of Applied Sciences, the VTT Technical Research Centre of Finland and Technopolis. The activities focused on the creation of centres of excellence (e.g. centre of Internet Excellence, Centre of Wireless Communication) and the creation of an open ubiquitous city in Oulu. From the user community's point of view such a city appears as a smart urban space providing rich interaction between the physical, virtual and social spaces. From the R&D community's point of view the city appears as an open community test bed stimulating innovation, research and development of new services and applications. The test bed enables urban computing research in

authentic urban setting with real users and with sufficient scale and time span. Fundamental hypothesis is that by deploying new pervasive computing infrastructure and new applications and services into the public urban space, a better place for people is made.

Oulu has aggressively developed its infrastructure which forms the core of what can be called an urban living lab where real-life user-centric innovations flourish. Oulu's living lab offers an environment for sensing, testing and piloting technological and social innovations. One example how City of Oulu drives for the Living Lab approach to obtain user-driven innovations is development of "test user community" tool in Tomorrow's Service Society project (EAKR/Council of Oulu Region). Test User Community tool "PATIO" (www.patiolla.fi) empowers ordinary people to experiment and contribute to development of new services or appliances. Another example is **development of learning environments**. How to renovate old schools or new school buildings to meet challenges of future learning? The Education Office in the City of Oulu is investing in future oriented thinking to develop learning environments to better match the learners and their needs. This foresight thinking is unique globally. Among the living labs created in the Oulu environment are OULLabs (Oulu Living Labs) and NorthRULL (Northern Rural Urban Living Lab). The applicability and benefits of Oulu's open ubiquitous city testbed has been demonstrated with many examples in collaborative industrial R&D and in engaging user communities. Some examples are the OmaOulu service giving citizens free access to e-services, the development of Future Schools and InnoLobby as a Learning Environment of the Future, the Smart Urban Spaces project and other.

It can be said that City of Oulu has been driving the Smart City ideas already from the early 90's. Many activities which have not been called at that time as a "smart city" or "Living Lab" have been done in co-operation with real end user, "an ordinary innovator". In early 2000, the City of Oulu advanced the catchword "Smart Oulu - Knowledge is the future" in the "Information Society City of Oulu" project. One of the examples of that project is the Smart Card (City Card) which was an ID-, access- punch- and payment card used by city employees and others involved to the project.

Even while there is an intensive collaboration between "Triple-Helix" stakeholders, it is still difficult to make all happen because of the different policies and priorities. The need to keep the "Smart City" architectural thinking continuously developing in terms of realizing plans towards results, combined with the need to continuously discuss and attract resources (time, people, facilities and money) sets the innovation ecosystem under pressure.

Available funding instruments and policies are not always supporting business development and spin-offs from research institutes. Policies have to be modified to enable to start commercialization of research results and help SMEs to do business with infrastructures developed with publicly funded projects. For example, in the future the public sector should be able to engage in innovative ways of procurement, so-called "early involvement process", when purchasing new e-services or software. In this process possible vendors will be taken into the loop in the early phase, to be able to avoid bidding but still taking care that everybody who would like to offer can do so.

Regional, national and international co-operation in developing Future Internet-enabled services have very crucial impact on the life of citizens. Citizens' (users) active participation in the economic activities plays an important role in the innovation process since citizens offer ideas and resources for innovation. Cities and Regions should therefore be fully involved in the process of governance and deployment of Future Internet services.

Table 3-6 presents the prospects of Oulu as a smart city in terms of a SWOT-analysis.

Strengths	Opportunities
• Ambitious research and innovation initiatives (Open Ubiquitous Oulu) • Strong leadership of the city • Innovation-friendly citizens • High level of cooperation and participation • Advanced ubiquitous wireless infrastructure	• Innovation leading to Entrepreneurship and new business creation • Oulu as technology leader, but also as innovation leader and as innovation ecosystem
Weaknesses	**Threats**
• Policies and funding instruments not always adapted to entrepreneurial development	• Reliance on ICT sector

Table 3-6: Oulu Smart City strategy - SWOT

3.8 A few remarks from the case studies

The six smart city cases demonstrate, besides the similarities as regards their future visions, some different approaches to the concept of "smart city" also. The different smart city concepts and profiles are summarized in the SWOT analyses. Clearly the six cities are at different stages of maturity and have been developed under different circumstances and using different strategies.

- It is also clear that the "smart city" is a strategy, not a reality yet. Several cities investigated, such as Oulu for example, are advanced in terms of technology infrastructure. However a smart city is more than technology and infrastructure; it is also a universe of smart applications and platforms which are empowering citizens in innovative ventures.
- Formation of innovation districts, neighborhoods, and clusters are fundamental elements of a smart city strategy, because the city is a system of systems, and cities co-exist within cities with variable management capacity and institutional control. Formulating smart city strategies in terms of smart districts and clusters offers also an advantage for exchanging good practice and solutions from one city to another, as cities are made from the same set of standard districts (CBD, housing, industrial, commercial, university campus, port and airport hubs, recreation).
- A smart city strategy involves many actors, organizations, communities, R&D, NGOs, clusters, and authorities. The strategy should achieve a common vision, flagship projects, collaboration and synergy. Top-down planning and bottom-up initiatives should complement each other.
- Major challenges for successful smart city strategies deal with skills, creativities, user-driven innovation, entrepreneurship, venture capital funding, and management of intra-government rivalries.

The cases, however, do not provide detailed evidence on how cities are realizing their vision. This implies that there is a need for even deeper analyses and case-based research on the transformation towards smarter cities. Table 3-7 illustrates key elements of the cases studies presented, which are further discussed in the final chapter.

	Helsinki	Thessaloniki	Manchester
Smart city concept	Helsinki as a Smart city cluster, including also the Helsinki region, in particular focusing on mobile and wireless technologies and applications.	"Intelligent Cities" as planning paradigm, focusing on districts and entrepreneurship	Urban regeneration driving economic change, focus on neighbourhoods eServices addressing inequalities and digital democracy Balancing top down and bottom up approach
Strategies towards "smart city"	Building a strong, knowledge-based and innovative cluster through collaboration Policy instruments such as pre-commercial procurement and Innovative City program.	Smart Districts building, supported by technology (wired / wireless networks, free Internet, smart environments based on sensors, e-service development). Creation of an "Agglomeration of apps"	Digital inclusion tackling skills and divides Digital industries for employment and creative sector Pro-active approach to economic and social change e.g. neighbourhoods
Main driving factors towards smart city	Strengthen Helsinki region, create entrepreneurial ecosystem	Deployment strategy of ICT and infrastructure in order to support the development of innovation ecosystem	Economic development strategy of Manchester Need for urban regeneration Development of a common "digital agenda"
Main challenges towards smart city	Enhancing the human capital base Enhancing entrepreneurial spirit and ecosystem	Digital skills gap; creativity gap; entrepreneurship gap	
Urban innovation ecosystem characteristics	Helsinki region Living Labs prominent role Public-private partnerships Public competitions for innovations	Innovation clusters, technology districts	Living lab approach (Eastserve, Manchester Living Lab) combined with local action. Networking city concept.

	Lisbon	Oulu	Barcelona
Smart city concept	Lisbon as international hub, pole of creativity and innovation, sustainability	Becoming the city of technology -> innovation city Aim to become the most highly developed city in Finland and Northern Europe	Implementation of ICTs to pursue social and urban growth; Smart City concept as a strategic tool; Infrastructures, Open Data, Service Innovation, Human Capital as pillars.
Strategies towards "smart city"	Active involvement of citizens in governance Facilitate creativity, providing the conditions to innovate. Strategy is based on three pillars: 1. Building spaces, 2. Fostering entrepreneurship, 3. Useful tools.	Aggressive development of the technological infrastructure, "ubiquitous Oulu"	Barcelona Smart City initiative; Smart District approach (22@Barcelona); integrated urban development approach including housing, environment, employment, knowledge economy; Urban Living Lab approach.
Main driving factors towards smart city	Attract business, create entrepreneurial climate, economic and social development	Policy and strategies of the Oulu municipality	City hall initiative and leadership combined with triple helix collaboration.
Main challenges towards smart city	Economic climate may hinder funding of projects	Adapt policies and funding instruments to entrepreneurial development	Collaboration among governmental departments; human capital and skills; global connectivity; funding for innovation.
Urban innovation ecosystem characteristics	Early phase of development	Strong PPP programmes, triple helix partnerships. Urban living lab	City hall initiatives and leadership; Triple helix model of collaboration among university, public sector and enterprises

Table 3-7: Overview of cities strategies towards becoming smarter

4. Assets and Infrastructures for Smart Cities Innovation Ecosystems

The smart city cases in the former chapter illustrate the need for continuous collaboration and communication among the various stakeholders, organisations, companies and citizens involved in building the smart city. This chapter looks into collaboration from the perspective of the infrastructures and resources underlying these smart city innovation ecosystems[8].

4.1 The need for collaboration for developing smart city innovation ecosystems

Partnerships and clear cooperation strategies among main stakeholders are needed in order to share research and innovation resources such as experimental technology platforms, emerging ICT tools, methodologies and know-how, and user communities for experimentation on Future Internet technologies and e-service applications. Common, shared research and innovation resources as well as cooperation models providing access to such resources will constitute the future backbone of urban innovation environments for exploiting the opportunities provided by Future Internet technologies. Three perspectives are addressed in this paper in order to explore the conditions for rising to this challenge (see Table 4-1).

	Future Internet Research	Cities and Urban Development	User-driven Innovation Ecosystems
Actors	Researchers ICT companies National and EU actors	City policy actors Citizen platforms Business associations	Living Lab managers, citizens, governments, enterprises, researchers as co-creators
Priorities	Future Internet technical challenges (e.g. routing, scaling, mobility)	Urban development Essential infrastructures Business creation	User-driven open innovation Engagement of citizens
Resources	Experimental facilities Pilot environments Technologies	Urban policy framework Organisational assets Development plans	Living lab facilities: methodologies & tools, physical infrastructures
Policies	Creation of advanced and testbed facilities Federated cooperation Experimental research	City policies to stimulate innovation, business and urban development Innovative procurement	User-driven innovation projects Open, collaborative innovation

Table 4-1. Three perspectives shaping the landscape of Future Internet and City Development

The first perspective of Future Internet research and experimentation represents a technology-oriented and longer term contribution to urban innovation ecosystems. Cities and urban areas provide a potentially attractive testing and validating environment. However, a wide gap exists between the technology orientation of Future Internet research and the needs and ambitions of cities. Hence, the second perspective is comprised of city and urban development policies. City policy-makers, citizens and enterprises are primarily interested in concrete and short-term solutions, benefiting business creation, stimulation of SMEs and social participation. While many cities have

[8] This chapter is partly based on papers developed in the context of the FIREBALL project: (1) H. Schaffers, N. Komninos, M. Pallot, B. Trousse, M. Nilsson, A. Oliveira (2011): "Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation". In: J. Domingue et al. (Eds.), The Future Internet. Springer; (2) H. Schaffers, A. Sällström, M. Pallot, J. Hernández-Muñoz, R. Santoro, B. Trousse (2011): "Integrating Living Labs with Future Internet Experimental Platforms for Co-creating Services within Smart Cities". Proceedings of the ICE 2011 conference, IEEE Xplore.

initiated ICT innovation programmes to stimulate business and societal applications, scaling-up of pilot projects to large-scale, real-life deployment is nowadays crucial. Therefore, a third perspective is the concept of open and user-driven innovation ecosystems, which are close to the interests and needs of cities and their stakeholders, including citizens and businesses, and which may bridge the gap between short-term city development priorities (demand pull) and longer term technological research and experimentation (technology push).

A key challenge is the development of cooperation frameworks and synergy linkages between Future internet research, urban development policies and open user-driven innovation. Elements of such frameworks include sharing of and **access to diverse sets of knowledge** resources and experimentation facilities; using innovative **procurement policies** to align technology development and societal challenges; and establishing **open innovation models** to create sustainable cooperation. The concept of open and user-driven innovation looks well positioned to serve as a mediating, exploratory and participative playground combining Future Internet push and urban policy pull in demand-driven cycles of experimentation and innovation. Living Lab-driven innovation ecosystems may evolve to constitute the core of "4P" (Public-Private-People-Partnership) ecosystems providing opportunities to citizens and businesses to co-create, explore, experiment and validate innovative scenarios based on technology platforms such as Future Internet experimental facilities involving SMEs and large companies as well as stakeholders from different disciplines.

4.2 Smart city innovation ecosystem resources such as testbeds and living lab facilities

In exploring the role of Future Internet experimentation facilities in benefiting urban development as we move towards smart cities, we will succinctly summarise the role of experimental facilities and the experimentation process, as well as the potential role of the 'Living Labs' concept in enriching experimentally-driven research on the Future Internet. Within the context of the developing portfolio of projects in the FIRE programme [European Commission 2010], the potential exists to support new classes of users and experiments combining heterogeneous technologies that represent key aspects of the Future Internet. The considerable obstacles of complexity and unfamiliarity that are faced when trying to explore the effects of new applications that bring future users the increasing power of the Future Internet have not yet been overcome. Issues that are being dealt with in the attempt of FIRE projects to move closer to the goal of a federated testbed facility, and which are also important in collaborating with smart city and Living Labs activities, are authentication and access to facilities; security and privacy as well as IPR protection; operation and research monitoring as well as experiment control; and the issue of defining and monitoring experiments in large-scale usage settings.

The portfolio of FIRE experimentation projects shows that users in such FIRE projects are mostly academic and industry researchers. End-user involvement and end user experimentation is beyond the current scope of FIRE, although some interesting initiatives in that respect have started such as the Smart Santander project (services and applications for Internet of Things in the city), the TEFIS project (platform for managing experimental facilities, among which Living Labs) and the ELLIOT project (co-creation of wellbeing, logistics and environment IoT-based services).

A comparison of the role of users in FIRE facilities projects compared to Living Labs is presented in Table 4-2. Importantly, FIRE projects typically involve users in assessing the impacts of technologies in socio-economic terms, whereas Living Labs projects aim to engage users in the innovation process itself. Also, the predominant approach of FIRE facilities is controlled experimentation, whereas Living Labs engage users in the actual innovation process (co-creation). The European Commission has voiced its support for stronger user orientation in the Future Internet facilities projects; not only users in the research community who will use these facilities for their research projects, but also end-users. Emphasis is on involving communities of end-users at an early stage of development to assess the impacts of technological changes, and possibly engage them in co-creative activities.

	Future Internet Experiments	Living Labs Innovation
Approach	Controlled experiments Observing large-scale deployment and usage patterns Federated testbeds	Both controlled and natural situation experiments User co-creation via Living Labs methodologies, action research Open, cooperative innovation
Object of testing	Technologies, services, architectures, platforms, system requirements; impacts	Validation of user ideas, prototype applications and solutions. Testing as joint validation activity
Scale of testing	Large-scale mainly	From small to large scale
Stakeholders	FI Researchers (ICT industry & academia)	IT multidisciplinary researchers, End-users, enterprises (large & SMEs)
Objective	Facilities to support research Impact assessment of tested solutions	Support the process of user-driven innovation as co-creation

Table 4-2: User Role in Future Internet Testbeds and Living Labs

In order to explore the opportunities and interfaces, we will now take a further look at Living Labs. The Web 2.0 era has pushed cities to consider the Internet, including mobile networks, as a participative tool for engaging citizens and city visitors. Many initiatives have been launched by cities, such as Wikicity in Rome stemming from MIT's Senseable City Lab which studies the impact of new technologies on cities, Real-Time City Copenhagen, and Visible City Amsterdam. This collection of initiatives already looks like a “networked Living Lab” of cities for investigating and anticipating how digital technologies affect people as well as how citizens are “shaping” those technologies to change the way people are living and working.

Apart from the diversity of research streams and related topics for designing alternatives of the Internet of tomorrow, it becomes increasingly challenging to design open infrastructures that efficiently support emerging events and citizens’ changing needs. Such infrastructure also creates many opportunities for innovative services such as green services, mobility services, wellbeing services, and playable city services based on real-time digital data representing digital traces of human activity and their context in the urban space. Environmental sensors measure parameters such as air quality, temperature or noise levels; telecommunication networks reflect connectivity and the location of their users; transportation networks digitally manage the mobility of people and vehicles as well as products in the city, just to give a few examples. Today, it is becoming increasingly relevant to explore ways in which such data streams can become tools for people taking decisions within the city. Promising applications and services seem to be emerging from user co-creation processes.

Recent paradigms, such as open innovation and open business models [Chesbrough 2003], Web 2.0 [O’Reilly 2009] as well as Living Labs [European Commission 2010], a concept originating from the work of William Mitchell at MIT and currently considered as user-driven open innovation ecosystems, promote a more proactive and co-creative role of users in the research and innovation process. Within the territorial context of cities, rural areas and regions, the main goal of Living Labs is to involve communities of users at an early stage of the innovation process. The confrontation of technology push and application pull in a Living Lab enables the emergence of breakthrough ideas, concepts and scenarios leading to adoptable innovative solutions. Some of the methodologies used in Living Labs innovation projects demonstrate a potential interface with FIRE experimentation approaches. In [Ballon et al. 2005], a useful classification is elaborated of different platforms for testing and experimentation including testbeds, prototyping projects, field trials, societal pilots and Living Labs. In [Pallot et al 2010] a landscape of user engagement approaches is presented. Methodologies for Living Labs organisation, phased development and process management

integrated with user experiments within an action research setting have been developed and implemented in [Schaffers et al. 2010].

Altogether, Future Internet experimental facilities, Living Labs and Urban development programmes can form an innovation ecosystem consisting of users and citizens, ICT companies, research scientists and policy-makers. In contrast with a testbed, a Living Lab constitutes a "4P" (Public, Private and People Partnership) ecosystem that provides opportunities to users/citizens to co-create innovative scenarios based on technology platforms such as Future Internet technology environments involving large enterprises and SMEs as well as academia from different disciplines. It appears that Future Internet testbeds could be enabling the co-creation of innovative scenarios by users/citizens contributing with their own content or building new applications that would mash-up with the city's open, public data.

4.3 Infrastructures for Smart city innovation ecosystems: emerging examples

Integrating Living Labs and Experimental Platforms

Experimenting and evaluating Future Internet (FI) technologies, services and user scenarios is not a trivial challenge due to the complexity of issues and diversity of stakeholders. This is especially true when different research communities are involved in this process through different methodology traditions such as 'Future Internet Research and Experimentation' (FIRE), 'Living Labs', 'Internet of Things' (IoT) and 'Smart Cities'. Further to this, engaging all stakeholders including communities of users/citizens for co-creating societal important Future Internet enabled services makes it even more complex. Today, involving users in research, design and innovation processes constitutes a fast growing topic as shown by the rapid growth of the European Network of Living Labs (ENoLL, www.openlivinglabs.eu) with currently more than 200 Living Labs. However, Living Labs need technology platforms such as the ones proposed by the FIRE community, where stakeholders jointly can co-create and evaluate new scenarios such as energy management, smart mobility, environment monitoring and homecare services that contribute to turn traditional cities into Smart Cities. The challenge is therefore to identify how to properly articulate Living Labs with FIRE and IoT testbeds in order to make sure that innovative services enabled by the Future Internet will meet the expectations and desires of user communities. In this section we study some examples of integration of Living Labs, Future Internet and Internet of Things platforms targeting service innovation, based on cases from FP7 projects TEFIS, SmartSantander and ELLIOT. A key objective is to propose a framework towards the development of Smart Cities' experimental environments based on such integration, with emphasis on mechanisms to ensure easy access and sharing of common research and innovation resources. Building on such mechanisms for openness and access to common resources, we envisage new patterns of collaborative innovation among stakeholders.

Bringing Together Methodological Approaches

Cities can be considered as "civic laboratories" [Institute for the Future 2010]. Whereas the current Internet and broadband infrastructure is already an indispensable component of urban innovation ecosystems nowadays, the emerging Future Internet constitutes a key infrastructural requirement for the future to fulfil the promise of the smart city concept [Komninos 2008]. Such innovation ecosystems will facilitate the co-creation of services within environments that stimulate open innovation and early end-user involvement.

Therefore, a challenge of paramount importance is to bring together the methodological approaches as well as facilities and resources of Future Internet projects [European Commission 2010] and of Living Labs initiatives [Bergvall-Kåreborn et al. 2009] within the policy setting of Smart Cities. In the field of living labs, both the C@R Integrated Project [Schaffers et al. 2010] and the currently running APOLLON project (www.apollon-pilot.eu) provide examples of sharing diverse resources such as technologies, service components, platforms, living lab facilities and business ecosystem concepts

across multiple pilots at different locations. Current FIRE projects create federated and interconnected experimental facilities for enabling experimental research. Future Internet experimental research primarily aims at investigating and validating innovative networking architectures and service paradigms. Several FIRE projects are targeting technologies and service concepts of high importance for end-user applications, such as Panlab (Web TV over mobile), TEFIS (mobile content sharing), Bonfire (on-demand applications) and SmartSantander (Internet of Things experimental facilities at urban scale). Other projects in FP7-ICT as well as in the CIP ICT-PSP also address Internet technologies, such as Internet of Things and sensor networks, and promote end-user involvement in co-creation, exploration, experimentation and evaluation (ELLIOT).

The FIRE community considers the ability to assess the impact of technological changes to the Internet in socioeconomic terms as an essential element. For that purpose it is necessary to involve user communities on a large scale at an early stage of development. Whereas FIRE stakeholders have been mainly targeting experimentation services to the R&D community, they have observed a need to enhance end-user support and involvement, which is considered as a relatively new area. They may benefit from the methodologies of mature Living Labs within the European Network of Living Labs. In a Living Lab, relevant stakeholders are integrated in a flexible service and technology innovation ecosystem. Bringing users at an early stage into the research and innovation process allows all stakeholders including business and industry to discover new scenarios and emerging patterns of behaviours as well as new usages, and to assess the socioeconomic implications of emerging technological solutions. In turn, Living labs may benefit from available technological facilities provided by FIRE experimental research projects.

Common Assets or Resources

In order to understand the opportunities for effective integration and common use of Future Internet, IoT and living labs resources, we aim to identify and characterise the “common assets” that are owned and used by different stakeholders and can be shared to constitute Smart City innovation ecosystems. Common assets include technologies, network infrastructures, methods, experiments and instrumentations, experimental and living lab facilities and user groups.

Asset type	Services offered
Network infrastructure	Broadband communication, enabling high bandwidth applications
Testbed facilities	Software /hardware platform for technology testing
Testbed methods	Testing and validation process
Living Lab facilities	User driven applications development
Living Lab methodology	User engagement, cyclic development, action research, data collection
Human capital	Expertise, know-how (Future Internet, applications, business)
User community	Availability of advanced users for experimentation and evaluation
Collaboration platform	Enabling interaction between users, developers, stakeholders
Technologies, know-how	Application opportunities
Public data, open data	Information, networked applications
Policy resources	Access to funding opportunities, organizational capabilities, networking enablers, innovation policies and programs
Capability to develop and run pilots	Capability to initiate and develop Future Internet and Living Labs projects to support smart city objectives
Social capital	Actor networks and actor relations, collaboration potential

Table 4-3: Common assets for Future Internet experimentation and Living Labs

Table 4-3 presents the typology of assets and the services offered by the assets. Common assets include human, organisational, technological and infrastructural resources and capabilities. Providing

access to and sharing common assets forms the foundation of collaborative partnerships that are underlying the transformation towards Smart Cities. The next section presents three cases that focus on identifying the common assets to facilitate such transformation.

As Table 4-4 illustrates, several FP7-ICT projects are devoted to research and experimentation on the Future Internet and the Internet of Things within cities, such as Smart Santander and, within the IoT cluster, ELLIOT. The CIP ICT-PSP programme has initiated several pilot projects dedicated to smart cities and Living Labs, some with a clear Future Internet dimension (Apollon, Periphèria, and to a less extent too, Open Cities and EPIC). Among the earlier projects with interesting aspects on the interface of Living Labs and Future Internet is the C@R Integrated Project (FP6).

Cities and urban areas	• Smart Santander (FP7-ICT, 2010). Internet services and sensor network in the city. www.smartsantander.eu • ELLIOT (FP7-ICT, 2010). Experimental Living Lab for Internet of Things. Three Living Labs are involved. http://www.elliot-project.eu/ • Periphèria (CIP ICT-PSP, 2010). Internet of Things in Smart City. www.peripheria.eu • Open Cities (CIP ICT-PSP, 2010). Public sector services. • EPIC (CIP ICT-PSP, 2010). Platforms for intelligent cities. • Apollon (CIP ICT-PSP, 2010). Domain-specific Pilots of Living Labs in cross-border networks, targeting city areas. www.apollon-pilot.eu
Villages in rural areas and regions	• Collaboration@Rural – C@R (FP6-ICT, 2006-2010). Six Living Labs in Rural areas using a common service platform. www.c-rural.eu • Networking for Communications Challenges Communities (N4C). Extending Internet access to remote regions. www.n4c.eu • MedLab (Interreg IVc). Living Labs and Regional Development.

Table 4-4: Examples of Living Lab Initiatives Related to Smart Cities, Rural Areas and Regions

Smart Santander, a City-wide Experimental Facility

The SmartSantander facility (www.smartsantander.eu) will be sufficiently large, open and flexible to enable horizontal and vertical federation with other experimental facilities and to stimulate the development of new applications by different types of users, including experimental advanced research on IoT technologies, and realistic impact assessment based on users' acceptability tests. The facility will comprise more than 20,000 sensors and will be based on a real life IoT deployment in an urban setting. The core of the facility will be located in the city of Santander and its surroundings, on the north coast of Spain. SmartSantander embraces the idea of enabling the Future Internet of Things to become a reality applying a living labs approach. Although the main target of SmartSantander is research oriented to create a large-scale testbed allowing open experimentation with key enabling IoT device technologies, it is obvious that such a kind of realistic setting grants the potential of involving real end-users in the experimentation process. A long list of potential applications has been identified by SmartSantander, in close cooperation with the City Council and the Regional Government of Cantabria, as suitable to be supported by the infrastructure being deployed. Most of them offer a big environmental and social potential: parking spaces and traffic control, environmental management and monitoring (pollution, CO_2, noise, etc.), public installations management (heating, A/C, lighting, etc.), public transportation, parks and gardens control (irrigation, etc), social assistance (elderly, disabled, etc.), etc. Due to time and budget limitations, during the execution of the project just some specific services will be deployed in order to validate the asset deployed. Other interesting and more advanced services are expected to come up later on as a result of parallel initiatives linked to the project at the regional level, as the project is committed to ensure the availability of the infrastructure beyond the end of the project.

TEFIS: Combining Different Testbed Resources and Living Labs Facilities

The TEFIS project (www.tefisproject.eu) supports Future Internet of Services research by offering a single access point to different testing and experimental facilities for communities of software and business developers to test, experiment, and collaboratively elaborate knowledge. It offers an open platform to access heterogeneous and complementary experimental facilities, including living lab facilities and testing tools to be used by service developers supporting the service development life-cycle. The platform provides the necessary services that will allow the management of underlying testbed resources throughout the entire service-development lifecycle. TEFIS is selected as example of bringing together Future Internet / IoT and living labs resources for the purpose of smart city innovations or other desired outcomes of the project because it constitutes:

- An experimental platform for Smart Cities development empowered by Future Internet technologies
- An open framework that will allow efficient combination of various experimental facilities to support the heterogeneity aspects of Future Internet experiments including the end-user involvement
- A platform to share expertise and best practices for higher "smartness" by shared intelligence and experiences.

Two main types of assets are available via TEFIS for future Smart Cities' experimentations: the platform and the testbed facilities provided by partners of TEFIS. The TEFIS platform is organised into four main functional blocks: the portal, core services (middleware), testbed connectors and user tools. It offers different types of support for Future Internet experiments such as designing, planning, management of experimental workflow, configuration assistance, experimental data management, reporting, knowledge sharing with other experimenters and access to different testbed facilities and service offers independent of geographical location. The testbed facilities provided by testbed partners of TEFIS include a wide spectre of testing and living lab opportunities.

The IP Multimedia System (IMS) testbed in Spain and the Botnia Living Lab in Sweden illustrate how in TEFIS experimental resources from different testing environments are combined and shared. The experiment is focused on a mobile application over IMS, and is divided into three different phases of the service development life-cycle: concept development, prototype development and business model definition. First, this experiment explores end-user feedback to check if the application is suitable and would be useful for users by access to Botnia Living Lab assets. In the second step, the IMS-testbed facilities are used as a validation tool to perform system acceptance testing (including functional and non-functional), and Botnia Living Lab is used for usability evaluation with end-users. In the third step, the correct business model for long-term sustainability is investigated. In this third phase both end-users feedback and network usage is monitored and analysed and for this the IMS testbed and Botnia Living Lab are combined.

ELLIOT: an Experimental Living Lab for the Internet of Things

The ELLIOT project (Experiential Living Lab for the Internet of Things) represents a clear example of Living Labs and Future Internet interaction, elaborating three IoT use cases in three different Living Labs. The first use case is dedicated to co-creation by users of green services in the areas of air quality and ambient noise pollution with innovative devices such as the "green watch" (http://www.lamontreverte.org/en/) and customised sensors being used by citizens. The second one addresses wellbeing services in connection with a hospital and the third focuses on logistic services in product development facilities with professional users. Its goal is to investigate evidence of the social dynamics of the Living Lab approach for the purpose of ensuring a wide and rapid spread of innovative solutions through socio-emotional intelligence mechanisms.

The green services use case takes place in the context of the ICT Usage Lab and within the Urban Community of Nice - Cote d'Azur (NCA). This use case involves local stakeholders, such as the regional institution for air measurement quality (Atmo PACA), the local research institute providing the IoT-based green service portal and managing the experiments (INRIA/AxIS), the Internet Foundation for the New Generation (FING) facilitating user workshops, and a local SME providing data access from electric cars equipped with air quality sensors (VULog) and a citizen IT platform (a regional Internet space for citizens in the NCA area). The objectives of the IoT-based green services use case are twofold: to investigate experiential learning of the IoT in an open and environmental data context, and to facilitate the co-creation of green services based on environmental data obtained via sensors. Various environmental sensors will be used, such as fixed sensors from Atmo PACA in the NCA area, fixed Arduino-assembled sensors by citizens, mobile sensors, such as citizen-wired green watches or sensors installed on electric vehicles. The backbone of the green services use case is an IoT-based service portal which addresses three main IoT-related portal services by allowing the user: 1) to participate in the collection of environmental data; 2) to participate in the co-creation of services based on environmental data; and 3) to access services based on environmental data, such as accessing and/or visualising environmental data in real time. Three complementary approaches have already been identified as relevant for the green services use case: participatory and user-centred design methods; diary studies for IoT experience analysis, and coupling quantitative and qualitative approaches for portal usage analysis. In this context of an open innovation and Living Lab innovation eco-system, focus groups involving stakeholders and/or citizen may run either online or face-to-face.

4.4 Integrating living labs and experiment platform resources

The cases addressed in the previous section demonstrate the possibilities of integration of or collaboration between different types of smart city resources such as testbeds, living labs and network infrastructures. The different resources or assets offer services that can be used according to needs within specific research and innovation projects. Ideally these services should be accessible for all those who want to engage in research, development, innovation and validation activities, addressing innovative technologies, applications and business models. It even can be foreseen that innovation projects may use and combine such resources in cross-border settings i.e. settings as explored within the TEFIS project (a testbed in Spain, a living lab in Sweden). **Such distributed resources may form the future backbone of connected regional and urban innovation ecosystems.**

This vision is far from realized however some initial case examples have been mentioned. It remains to be investigated what the realistic configurations of such integration or collaboration are and how services based on geographical distributed infrastructural assets (but also non-infrastructural assets such as knowledge and consulting services, large user group management etc) can be combined and offered, both from technical and from business model point of view. Of course, current testbeds and living labs fulfil very different roles, in different engineering contexts, focusing on different outcomes, with different actors involved and with different timelines. However we foresee a "decomposition" of the different traditional resources and facilities and subsequent recombination of them, offering services on demand in research and innovation projects. This is important as Internet-based systems are increasing in complexity and traditional engineering methods are becoming less useful. Systems need to be evolutionary and adaptive as they are based on emergent and non-linear behaviour. Testing a system to meet a set of requirements still has its part to play (e.g. compliance) but new approaches are necessary to help researchers, systems developers and users to understand system behaviour. There is a need for a systematic experimentally driven methodology hat considers how socio-economic and technical factors influence specific ICT innovations. Such methodologies may also accelerate the developments towards smarter cities. This is a direction that might be explored within Horizon 2020.

Operational collaboration among Future Internet, Living Labs and Smart Cities initiatives and resources requires the definition of collaboration processes and infrastructures around a specific innovation activity. Both TEFIS and ELLIOT have come up with simple and realistic models (Fig. 4-1). Within TEFIS a simple collaboration model has been elaborated for the purpose to serve an experimenter and to boost the usage of different assets from individual facilities as a unified service-offer to attract more users of the facilities and to be able to serve the fully service development life-cycle of a Future Internet service developer. In the first phase, Botnia Living Lab is used as a design tool facility. The second phase of prototype validation utilises functional testing capabilities of IMS facility (IP Multimedia System). The third phase of business validation builds on joint use and integration of Botnia Living lab and IMS facility. For ELLIOT, a more concurrent collaboration model is experimented built upon cycles of co-creating service scenarios and evaluation of the innovative concepts in a usage lab, experimentation in an IoT testbed, and evaluation in a usage lab. An important challenge is to explore and investigate the different collaboration models and the governance principles underlying this collaboration and sharing.

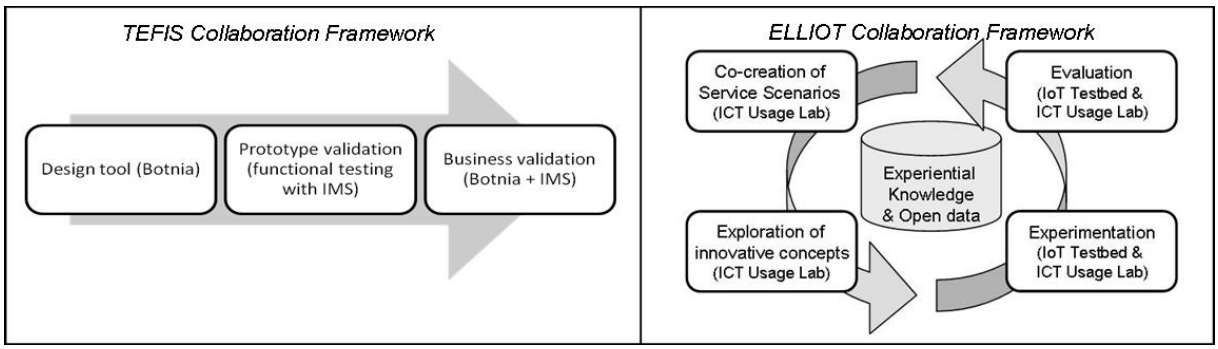

Fig. 4-1: Testbed and living lab integration models from TEFIS and ELLIOT

These emerging cases lead us to propose a governance framework for interested parties in different Future Internet, Living Labs and Smart Cities communities to create collaboration models for sharing capabilities and resources offered by existing platforms, testbeds and living labs facilities. The framework defines arrangements related to IPR management, legal issues and partnership agreements to implement an open innovation approach for transformation towards Smart Cities. The common assets to be made available to the members of the communities are of a different nature ranging from know-how, to software or user communities and thus require different business and legal arrangements and access mechanisms characterised as follows:

- Ownership: the legal entity owning the asset can make it available to the Communities. Ownership can be jointly owned as often is the case in RTD projects. In this case special access conditions are normally granted to the project participants for the use of projects results. In research and innovation projects, this term means licences and user rights to foreground results or background Information and intellectual property.
- IPR Intellectual Property Rights: intellectual Property: any patent, registered design, copyright, design right, database right, topography right, trade mark, service mark, application to register any of the aforementioned rights, trade secret, right in unpatented know-how, right of confidence and any other intellectual or industrial property right of any nature whatsoever in any part of the world; IP can be made available to others through a Licence.
- Access Conditions: such access conditions can be Free, Preferential or at Market value.
- Access Mechanisms: the actual access to the assets is granted trough a contractual arrangement (typically for accessing tangible assets) or open licence mechanisms such as Creative Commons (typically for methodologies) or General Public Licences (typical of Open Software).

The Future Internet, Living Labs and Smart Cities communities are creating a wide variety of common assets, which they may wish to make available to all communities. To support that goal, the basic approach suggested is to create a "catalogue" where each organization is responsible to update the description of its assets in the catalogue (e.g. using a wiki approach). All the shared assets will be included in the catalogue together with the information and the processes to access them. Each organization maintains its independence and any ownership rights are not affected by this process of virtual collaboration. The proposed governance structure is based on the well-established organisational forms of Collaborative Networked Organizations [Camarinha-Matos, Afsarmanesh, Ollus 2008]. Implementation of this governance structure could proceed through establishment of an open association of legal entities which would intend to favour the launch of Future Internet Experimentations projects in real life environments (i.e. pilots). Each member of this association would provide the description and access mechanisms for their owned assets. Within the FIREBALL project, an initial scheme for the legal framework and IPR management of the proposed association has been proposed. Such access and sharing of common assets may provide a solid foundation for cooperation models, for example at the urban and regional level but also international cooperation models may be envisaged, as explored within the APOLLON project on cross-border living labs services.

4.5 Collaboration for urban and regional innovation and development

These examples provide initial concepts of collaboration models in smart city innovation ecosystems, governing the sharing and common use of resources such as testing facilities, user groups and experimentation methodologies. Two different layers of collaboration can be distinguished. The first layer, explored in the previous section, targets collaboration *within the smart city innovation environment*, which is understood as ongoing multi-actor interaction between research, technology and applications development and validation and utilisation in practice. Cases mentioned above such as ELLIOT and SmartSantander constitute typical "innovation ecologies" where potential orchestrations of these interactions are explored. Still, many issues need to be clarified such as how the different research and innovation resources in a network, such as specific testing facilities, tools, data and user groups, can be made accessible and adaptable to specific demands of any research and innovation projects.

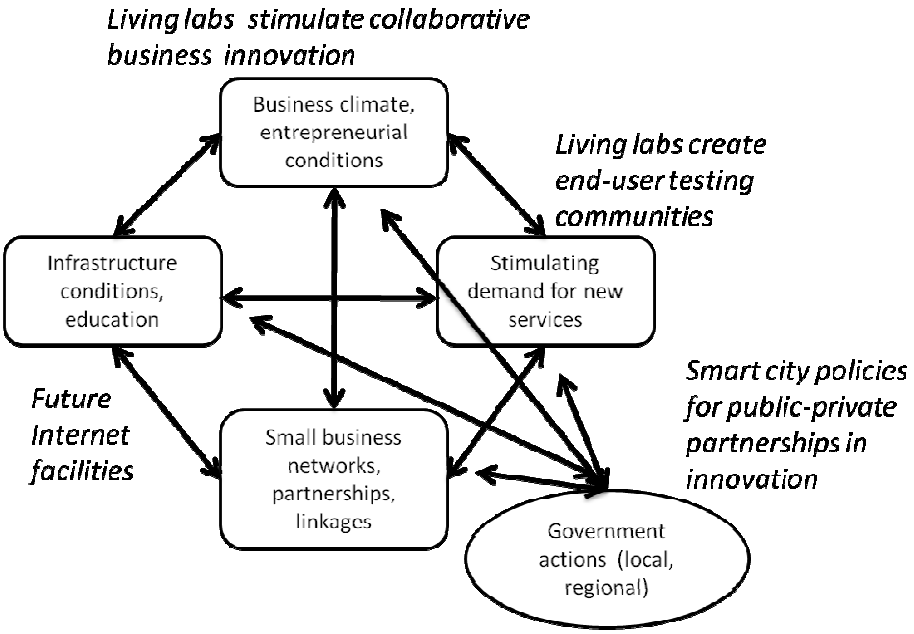

Fig. 4-2. Conceptualisation of smart city value creation and innovation system (adapted from Porter, 1990)

The second layer concerns *collaboration at the territorial level*, driven by urban and regional development policies aiming at strengthening the urban innovation systems through creating effective conditions for sustainable innovation. This layer builds on Michael Porter's concept of "national competitive advantage" [Porter 1990] which borrows the 'national systems of innovation' thinking, which was originally developed by Christopher Freeman. Following this thinking, the "urban value creation system" can be considered as being shaped by four determinants: 1) resources, skills, technologies, physical and immaterial infrastructure, 2) networks and collaboration, 3) entrepreneurial climate and business networks, 4) demand for services and availability of advanced end-users (see Fig. 4-2). Additionally, the value creation system in its conceptualisation by Michael Porter is affected by policy interventions aimed at stimulating the building of networks, the creation of public-private partnerships, and the enhancement of innovative conditions. The smart city cases in the previous chapter provide many illustrations of these interventions.

The challenge in this layer is to create a collaborative approach to innovation ecosystems based on sustainable partnerships among the main stakeholders from business, research, policy and citizen groups and achieve an alignment of local, regional and European policy levels and resources. The ELLIOT project is an example of a Future Internet research and innovation project embedded in regional and even national innovation policy. From the perspective of smart cities, managing innovation at the level of urban innovation ecosystems becomes a task of managing the portfolio of resources and fostering fruitful inter-linkages. Smart city innovation ecosystem management aims to manage the portfolio of "innovation assets" made up of the different facilities and resources, by creating partnerships among actors that govern these assets, by fostering knowledge and information flows, and by providing open access to resources made available to users and developers.

5. Balancing Bottom-up and Top-Down: Engagement towards Smarter Cities

Urban development and planning has been dominated by top down "blueprint" approaches since long. At the same time there have always been "grassroots" developments based on empowering communities of citizens. These grassroots developments now have become considerably stronger, as they currently are supported by a wide spectrum of social media / web 2.0 technologies[9]. This chapter investigates the balance between top down and bottom up approaches and ways to strengthen the balance.

5.1 The current policy context of cities

The current economic climate forces many cities to cut budgets and set priorities and this affects the lives of citizens. Cities are facing tough challenges to maintain and upgrade ICT infrastructures and innovation policies. Creation of a common, community supported, agenda or roadmap for urban innovation and economic development as enabled by ICTs and the Future Internet, supported by all stakeholders and addressing priorities of cities and citizens, may help finding consensus on both short term and longer term objectives. Stimulating social innovation, to benefit the creation of solutions to major social problems in cities using the technological opportunities of the Internet, should be in the heart of this effort.

Future Internet research programs are based on the belief that the current Internet has reached his limits [Tselentis et al. 2010]. However, there are still open questions such as articulating the various relevant research areas, methods and tools from which new technologies, applications and services will emerge as well as the feasibility to combine technology push and application pull approaches. For research on the Future Internet to benefit not only research communities but also SMEs, citizens and cities it is important to integrate the research and experimentation perspective with the concept of user driven open innovation.

The Smart Cities concept, also endorsed by the EUROCITIES community (www.eurocities.eu), is connected to notions of global competiveness, sustainability, empowerment and quality of life, enabled by broadband networks and modern ICTs. Its implementation requires the development of migration paths regarding Internet infrastructures, testbed facilities, networked applications, and stakeholder partnerships. Informed by technological opportunities, future development strategies and cost-benefit assessments, cities should develop priorities regarding socially and economically desirable applications, based on strategic objectives regarding economic and social development of city areas. Resources contributed by different stakeholders that might be shared by stakeholders to realize smart city strategies include Living Labs facilities, Future Internet research and testing facilities, cloud computing, as well as web-based methodologies, software tools and managed user communities.

Whereas this approach still remains valuable, it risks the danger of becoming disconnected from social and economic reality in cities. There is a need to connect to real problems and issues and to grassroots movements aiming to empower citizens and businesses.

The FIREBALL project explores how cities and urban areas represent a critical mass when it comes to shaping the demand for advanced Internet-based services in large-scale testing and validation. Shaping this demand informs ongoing research, experimentation and deployment activities related

[9] This chapter is based on the paper: N. Komninos, H. Schaffers, M. Pallot (2011): "Developing a Policy Roadmap for Smart Cities and the Future Internet". eChallenges e-2011 Conference Proceedings. Besides on the roadmap approach presented in the D2.1 Landscape and Roadmap of Future Internet and Smart Cities (2nd version May 2011, final version April 2012).

to Future Internet testbeds, and helps establishing a dialogue between the different communities involved in the development of the future Internet and user-driven environments, to form partnerships and assess social and economic benefits and discovery of migration paths at early stages. Development of an "agenda towards smarter cities" will strongly contribute to establishing this dialogue, but only if citizens communities are taking the lead.

5.2 Agenda setting and roadmapping: balancing bottom-up and top down

To support such agenda building processes, top down planning seem not sufficient. Cities should support the emergence of empowered communities of citizens and other stakeholders and establish new forms of dialogue and debate, which are based on engagement, information and knowledge sharing and on collaboration.

We offer some thought about how the opportunities of future Internet technologies on smart cities could be explored and exploited in the public dialogue, based on a mixture of research of literature, cases studies on experimental facilities and discussions within the Fireball community of cities, companies and research institutes. The corpus of literature we are taking into account includes a variety of sources such as (1) the EU FP7 research on future Internet technologies, future media Internet, future media networks, experimental facilities of FIRE, and research on smart cities from the Competitiveness and Innovation Programme; (2) OECD reports and governmental papers on the future of the Internet economy and strategic policy directions; (3) large companies research programmes in the field of intelligent and smart cities; (4) reports by consulting groups on emerging technology trends; (5) recent Gartner surveys (2009 and 2010) on Emerging Technologies which illustrate different societal expectations, interest about and use of technologies; and (6) foresight exercises about the future of cities presented by academic institutions and the Institute for the Future.

These foresight estimations and experiences drive the Smart Cities thematic innovation roadmap which we have elaborated within FIREBALL. This thematic roadmap approach and its results documented in the FIREBALL D2.1 "Landscape and Roadmap of Future Internet and Smart Cities" acts as a framework that provides a basis for more elaborated smart cities action plans and planning processes. The thematic roadmap approach is based on four key questions:

- What is changing in the domain of smart cities and the future Internet?
- What is the future vision for smart cities based on future Internet scenarios?
- What are the challenges and gaps to be addressed for realizing the vision?
- What are the niches of novel solutions to the envisaged gaps and challenges?

The first step of the roadmap process is to identify the **emerging changes** in the domain of Smart Cities and their innovation ecosystems, which represent the seeds of developments towards exploiting the opportunities of Future Internet and Living Labs. Changes that we have identified are:

- Increasing deployment of broadband infrastructure and creation of open networks and open data repositories
- Many cities are developing Smart City strategies, in the context of urban development, sustainable growth, revitalisation, and innovation districts
- Increasing participation and empowerment of citizens in societal issues, using social media and open data on a wider scale
- Increasing interest for wider scale testing of services and solutions e.g. energy efficiency, healthcare, environment monitoring, mobility

- Diversity of technologies for smart city applications is becoming rapidly available (mobile broadband, cloud computing, open data, smart devices, content management, Web 2.0)
- User driven open innovation in cities (e.g. crowdsourcing services based on sensor data) is gaining more attention
- All kinds of city managed data could become publicly available to promote crowdsourced services and bottom-up innovation (however, this may also be misused).

The second step is to **develop a scenario representing the future of Smart Cities**. Elements of such scenario are the following:

- Smart city digital innovations enable the forecast and management of urban flows and encourage collective intelligence within cities
- Smart enterprises, collaborative business networks, smart energy and health systems, social media and open data are key enablers for smart cities quality of life and sustainable growth strategies
- Future Internet successful development and uptake depends on cooperation along the value chain and user driven innovation to establish sustainable urban innovation ecosystems as "civic in-situ laboratories"
- Cities are a key driver of innovation in Future Internet enabled services and applications. City-based 4P innovation ecosystems develop across existing constituencies and resolve barriers in take up of Future Internet.
- Future Internet testbeds will be enriched by living labs approaches through user co-created applications and services
- Providing access to, and enabling sharing of common assets and resources owned by the different constituencies lies at the basis of these innovation environments.

The third step is to **identify the challenges to realize the future vision**, and the gaps relative to the current state of affairs. These include:

- Smart city digital innovation for cohesiveness: competitiveness, inclusion, innovation and skills, employment and entrepreneurship, and for sustaining the innovation economy of cities
- Smart city digital innovation should address societal and urban challenges: energy efficiency, environmental quality, healthcare. Integrate designed and grassroots solutions
- Create the digital and immaterial infrastructure of smart cities and establish partnerships and business models
- Create rich environment of (fixed and mobile) broadband networks supporting digital applications: networks, sensors and devices, applications
- Create end-user driven and participatory innovation environment on city-wide scale based on sustainable partnerships and willingness to experiment and learn e.g. on cloud computing, Internet of Things, open data, semantic web, future media technologies
- Combine technology push and application pull approaches (e.g. end-user driven and learning-by-doing models). Consider cities as socio-technical systems and address socio-technical change from holistic perspective. Address potential new divides.

Following this step-wise roadmap a series of solutions can be identified in a diversity of areas (as summarized in Fig. 5-1):

- *Innovation ecosystems* based on integrating policies for urban development, revitalisation and digitisation, smart environments harnessing collective intelligence and user driven innovation, and experimentally driven Future Internet research.
- *Ubiquitous smart city broadband infrastructures*: smart city open network infrastructures and services, wireless sensor networks enabling smart systems, smart personal devices, open data infrastructures, cloud computing, public ambient interfaces, Internet of Things
- *Open city platforms* (`i-phone cities`) enabling the creation of products by citizens, including marketing and delivery
- *Technologies and components*: Content management tools; Collaboration tools; Cloud services and software components to build networked applications; Smart systems based on Internet of Things; semantic web and M2M communication
- *Enabling the access and sharing to common assets:* open data repositories, experimentation facilities, and testbeds, user communities for validating new services, technology platforms and experimental know-how, IPR for open data
- *Simplification of programming languages,* enabling user-generated services and harnessing mass IT literacy.

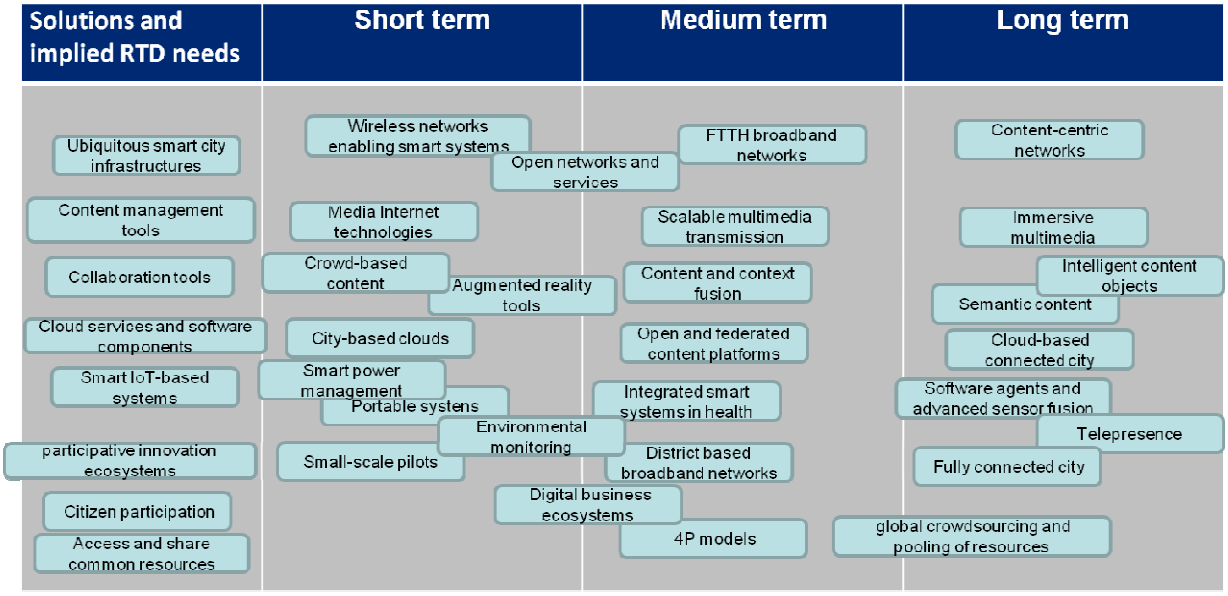

Fig. 5-1: Thematic Roadmap of Smart Cities and the Future Internet (summary)

5.3 Examples of roadmapping technological opportunities for smart cities

We further analyzed some of the developments, vision elements, challenges and solutions inspired by an **innovation roadmap methodology** which is based on applying the systemic concepts of transition, niches and regimes, and social change [Geels 2006, Kemp et al. 1998] to roadmap development, as elaborated in [Kömölla 2007]. This approach considers four dimensions of upcoming trends: technological changes, business changes, policy changes, and societal changes. The concept of "niche" indicates emerging and radical innovations that have the potential to modify existing value networks (or "regimes"). Within the context of "smart cities", a combination of innovative projects, policy instruments, open experimentation environments such as living labs, empowered citizens and disruptive technologies can be expected to shape such "niches".

In elaborating the roadmap, we focus in particular on developments and impact of three main Internet-based technologies: **cloud computing; real-world user interfaces of sensors, tags and**

RFIDs; and the semantic web. The aim is to assess the expected effects of these technologies on smart city solutions and operations, and the resulting changes on informational and cognitive processes of information collection and processing, real-time alert, learning, collective intelligence and problem solving, which characterize smart cities.

The Future Internet domain landscape comprises a great diversity of research streams and related topics for designing alternatives of the Internet of tomorrow. For example, the Internet of Things (IoT) is considered as a major research and innovation stream leading to create plenty of service opportunities in interconnecting physical and virtual worlds with a huge amount of electronic devices distributed in houses, vehicles, streets, buildings and many other public environments. Hence, a massive amount of data will be flowing over the Internet that should not decrease the overall service performance and satisfaction. [Calabrese et al. 2009] propose to examine the four key components of a real time control system: entity to be controlled in an environment characterized by uncertainty; sensors able to acquire information about the entity's state in real-time; intelligence capable of evaluating system performance against desired outcomes; physical actuators able to act upon the system to realize the control strategy. This perspective corresponds to new technology paradigm of embedded spatial intelligence and intelligent cities. The Institute for the Future [Townsend et al. 2011] has also identified some major trends of the future Internet technologies on smart cities, which emerge, among others, from cloud computing, smart sensors and devices, and open data.

Cloud Computing and Smart Cities

Cloud computing is based on several technology advances related to high-speed networks, virtualisation, and mainly standardisation of platforms and applications. However, "cloud computing is a new way of delivering computing resources, not a new technology" [Australian Government 2011], providing computer services through the Internet and a series of new business models of outsourcing. The National Institute for Standards and Technology offers a stylized description of cloud computing as composed of **five essential characteristics** (on-demand self service, ubiquitous network access, metered use, elasticity, and resource pooling), **three service models** (software as a service-SaaS, platform as a service-PaaS, and infrastructure as a service-IaaS), and **four deployment models** (private, community, public and hybrid clouds) [Mell and Grance 2011].

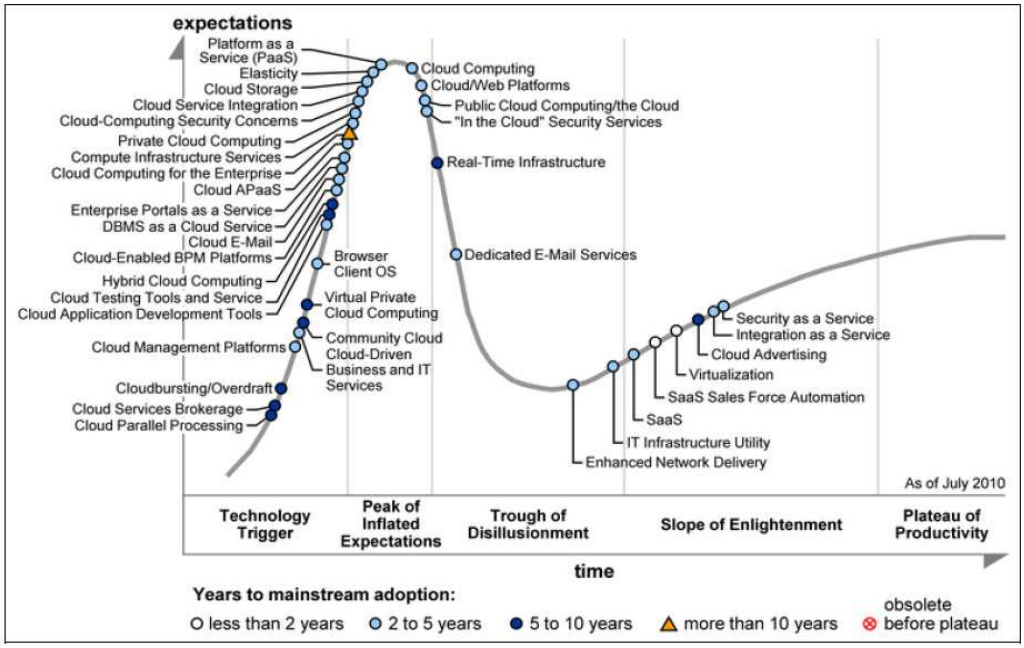

Figure 5-2. Gartner hype of cloud computing [Gartner 2010]

Foresight estimations about developments in cloud computing is given by the Gartner Hype Cycle for Cloud Computing [Gartner 2010], which is positioning 38 technologies of the field at different stages of the Hype Cycle (Fig. 5-2).

In this type of analysis, each Hype Cycle is composed of five stages representing the typical progression of an emerging technology: (1) "Technology Trigger" or technology breakthrough and product launch that generate significant interest of the press, (2) "Peak of Inflated Expectations" the phase of over-enthusiasm and unrealistic expectations, (3) "Trough of Disillusionment" of reduced press interest because technologies fail to meet expectations and quickly become unfashionable, (4) "Slope of Enlightenment" with experimentations about the benefits and practical application of the technology, and (5) "Plateau of Productivity" in which the benefits of technologies become widely demonstrated and accepted. Expectations about cloud computing are very high. Most technologies, however, are at the "technology trigger" stage, and cloud computing overall is at the peak of expectations, a few solutions are at experimentation stage, and none at the stage of demonstrated results. The time frame for these solutions is from 2 to 10 years, and only virtualisation and software as a service are closer to mainstream adoption.

Cloud computing and its impact on smart city solutions has been discussed in several forecast publications for 2020 [Townshend et al 2009, 2011]. While in the short-term, cloud computing will be delivered by large commercial clouds, government G-clouds are promising models for (larger) cities, creating urban clouds that reduce IT costs, and providing platforms for small business applications and e-services. Cloud computing is opening also new possibilities in virtualisation of physical spaces and substitution by digital ones. Already because of global 2009 crisis many activities and networks, from R&D to markets, go virtual allowing companies and organisations to maintain operations in times of austerity, gaining flexibility and lowering fixed costs. It sustains new growth sectors of cities, which are now moving from manufacturing to services in the framework of a wider movement from products to services, as material and intangible infrastructures start being provided by the cloud.

Extremely important is the expected standardisation of smart city systems, platforms, and applications, which is necessary to provide on-demand self services. Standardisation will accelerate technology diffusion and learning curves as city administrations and their IT departments will become aware of proven solutions for the main districts and sectors of the city. We should expect a standardisation of platforms and applications in about 20 different domains of cities, related to typical city districts (CBD, manufacturing, housing, education), city utilities (transport, energy, water, broadband), and city management (administration, democracy, planning). Collaborative innovation ecosystems may emerge in these areas.

Real-world User Interface, Sensors, RFIDs and Smart Cities

Internet-of-Things including sensor networks and RFID is another important emerging strand. These technologies may overcome the fragmented market and island solutions of smart city applications and provide generic solutions to all cities. Examples of generic architecture include networked RFID tags (passive and active tags, mobile devices), sensor networks (multimodal sensors and actuators, built-in intelligent agents), and connected objects such as distributed intelligent systems, intelligent objects and biometrics [Lemke 2010]. A new round of applications, such as location aware applications, speech recognition, Internet micro payment systems, and mobile application stores, which are close to mainstream market adoption, may offer a wide range of services on embedded system into the physical space of cities. Augmented reality is also a hot topic in the sphere mobile devices and smart phones, enabling a next generation location-aware applications and services [Gartner 2010].

While the future uses of IoT technologies that will bridge the physical and virtual worlds are still largely a matter for speculation, there are estimations that they will bring significant economic benefits. The OECD policy guidance encourages research on economic and social impacts and foster

business R&D encouraging technological neutrality, open global standards, and harmonization of frequency bands [OECD 2008].

Embedded networks of sensors and devices into the physical space of cities are expected to enable a new type of spatial intelligence, advancing further the capabilities created by web 2.0 applications, social media and crowdsourcing. A real-time spatial intelligence having a direct impact on the services cities offer to their citizens. The concept of spatial intelligence of cities refers to mechanisms that make a city intelligent or smart and allows unifying those of "intelligent city" and "smart city" under a common field of study focusing on their underlying informational and cognitive processes (http://en.wikipedia.org/wiki/Spatial_intelligence_of_cities). Internet of Things brings us closer to the way William Mitchell [Mitchell 2007] has described the intelligence of cities as residing in "the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence)". Collective intelligence and social media has been a major driver of spatial intelligence of cities. Social media have offered the technology layer for organizing collective intelligence, with crowdsourcing platforms, mashups, web-collaboration, and other means of participatory problem-solving. Now, the turn to embedded systems highlight another route of spatial intelligence based on location accurate and real-time information. Smart cities with instrumentation and interconnection of mobile devices and sensors can collect and analyse data and improve the ability to forecast and manage urban flows, thus push city intelligence forward [Chen-Ritzo et al 2009]. For this type of embedded spatial intelligence important is the development of Urban IoT platforms offering a common framework for ambient sensor networks as intelligent information infrastructure under universal ubiquitous sensor network architecture [Hernández-Muñoz et al 2011].

Semantic Web, Linked Data, Ontologies and Smart Cities

The OVUM report on smart cities [Ovum 2011] considers cloud computing and the IoT as fundamental layers of ubiquitous connectivity on which stands a layer of open public data and advanced analytics for fast-based decisions. The open standards trends have expended to government data and many agencies are providing access to datasets stimulating the creation of applications for information retrieval and decision making. Open data from various sources, government, sensors, citizens and businesses, offer opportunities for advanced analytics and intelligence to detect patterns, generate alerts, visualise information and predict trends.

In data-driven decisions, techniques for forecasting and predictive analytics are well established in many domains. What is relatively new is the semantic meaning provided by ontologies, like the Good-Relations annotator tool for creating rich RDF meta-data describing products or services and the introduction of HTML5. The cloud will offer additional functionalities for linked data as any object will be related to objects contained in the cloud. The semantic web is expected to breaks down barriers, merging data from different sources and presenting it in meaningful way. Social media based collaboration and collective intelligence can reach a higher level of efficiency and information accuracy.

Future media research and technologies offer a series of solutions that might work in parallel to Internet of Things and embedded systems providing new opportunities for content management. Media Internet technologies is at the crossroads of digital multimedia content and Internet technologies, which encompasses media being delivered through Internet networking technologies, and media being generated, consumed, shared and experienced on the web. Technologies enabled by the functionalities of the Future Internet, such as content and context fusion, immersive multi-sensory environments, location-based content dependent on user location and context, augmented reality applications; open and federated platforms for content storage and distribution provide the ground for new e-services within the innovation ecosystems of cities.

Engagement of users and user driven innovation are important preconditions for success. The Web 2.0 era has pushed cities to consider the Internet (including mobiles) as a more participative tool for engaging citizens and tourists. Many initiatives were launched by cities. It already looks like an example of several cities based Living Labs for investigating and anticipating how digital technologies will change the way people live in the city and their implications at the urban dynamics.

Altogether, Future Internet, Living Lab and Smart City form an intelligent innovation ecosystem comprising users/citizens, ICT companies, research scientists and policy makers. In this ecosystem, while the Future Internet represents the technology push, Smart Cities represent the application pull and Living Labs form the exploratory and participative playground in between the FI technology and Smart Cities' applications. In contrast with a testbed, a Living lab constitutes a 4P (Public, Private and People Partnership) ecosystem that provide opportunities to users/citizens to co-create innovative scenarios based on technology platforms such as FI technology environments involving large enterprises and SMEs as well as academia from different disciplines. It appears that Future Internet testbeds could be enabling the co-creation of innovative scenarios by users/citizens contributing with their own content or building new applications that would mash-up with city open public data.

5.4 An agenda and milestones towards smarter cities

The above discussion on the evolution of the web and the emerging future Internet technologies and the lessons learnt from the case studies allows defining some key elements of a roadmap towards smart cities. Cities are increasingly aware of the concept of "smart city" and actively developing strategies towards the goal of becoming "smart" and manage more efficiently city resources and addressing development and inclusion challenges. Part of the development towards smart cities is the co-creation-crowdsourcing paradigm, people-led testing and implementation of technologies and ICT-based applications in sectors such as health and assisted living, participative government, energy management, and new work environments. This is a fundamental trend of smart cities: defining and implementing solutions with the involvement of citizens and transforming through the participation of users the traditional city planning model from top-down to bottom-up.

The smart cities roadmap summarized in Table 5-1 focuses on Cloud and Internet of Things technologies and is based on a two-dimensional mapping of layers and time periods. The vertical dimension considers the following layers related to evolving Internet technologies: technological change, business change, policy change and social change. The time dimension includes the short term, mid-term and longer term developments in the field of smart cities. In order to enhance the policy relevance of the roadmapping approach, we focus on the systemic character of innovations related to smart cities, which require concurrent processes of socioeconomic and technological change. To provide guidelines to this process, the roadmapping approach draws from systemic change literature taking into account several characteristics of systemic change which relate to the transformation towards smart cities, e.g. regimes, barriers, transitions, and niches of novel solutions. The innovation roadmap highlights a series of themes at the intersection of future Internet technologies and smart cities. Recurrently, at multiple sections of the roadmap appear the transition to the cloud, smart city pilots, and city-wide open platforms of embedded systems. These areas are of primary importance for city authorities all over the world that are deploying strategies for smart cities, e-infrastructure and e-services to address the contemporary challenges of competitiveness and sustainable development. Thus, the roadmap allows formulating some policy recommendations to city authorities for mastering the new interdisciplinary planning for intelligent or smart cities and the interlinked layers of digital technology, people-driven innovation ecosystems, urban activities and infrastructure.

The **transition to cloud-based solutions** represents a key technological and business change which is expected to profoundly affect a transformation towards smarter cities. Policy white papers about the transition to the cloud provide valuable guidance to city authorities because these technologies are

still evolving and have not yet fully addressed the issues of services standardisation, security, and privacy. The recommendation is for streams of consultation work, providing public agencies with guidance and documentation, cost and benefit analysis, development of services in less important areas initially, and then go on full deployment of new cloud-based services, and eventually the creation of G-city clouds. A recent report [Australian government 2011] offers a global scan of public policies and programs addressing the transition to cloud computing in the US, UK, EU, Canada, and Japan. City authorities should also become aware that IoT solutions will increase dramatically the demand for broadband connections at the transition from connecting people to connecting things. Network interoperability and merging of network and media technologies, as well as machine to machine communication (M2M) allowing both wireless and wired systems to communicate with other devises of the same ability, will be necessary to cover the broadband demand in the public space of cities.

REGIME	***Short term (2014)***	***Medium term (2017)***	***Long term (2022)***
Technological change *(Dominant designs, emerging technologies, interoperability)*	-CLOUD: Virtualisation -CLOUD: IaaS for smart cities	-CLOUD: Web platform -CLOUD: SaaS for smart cities - Content-context fusion	-CLOUD: PaaS for smart cities -CLOUD: Service integration
	-IoT: RFID -IoT: Speech recognition -IoT: Open data apps	-IoT: Multimodal sensors -IoT: Location aware apps,	-IoT: Urban IoT platforms -IoT: Cloud based ontologies -Content-centric networks
Industrial change *(Networks of technology developers, alliances, standardisation)*	-CLOUD: Large companies clouds, Google, MS, Amazon global clouds	-CLOUD: Large cities clouds	-CLOUD: Standardisation of smart city applications / services
	-IoT: Sensors into utilities and energy networks	-IoT: Alliances of large companies and major cities	-IoT: Large scale applications
Social change *(Behaviour, routines, values, preferences, demand, end-users)*	-CLOUD: Reduction of IT costs	-CLOUD: Security issues raised -CLOUD: Disaster management addressed	-CLOUD: Continuity of service -CLOUD: Learning curve
	- IoT: Experimental facilities -IoT: A few city pilots	-IoT: Multiple city pilots	-IoT: Large scale demand for sensor-based city infrastructure
Policy change *(Regulations, economic instruments, governance, agreements)*	-CLOUD: Transition white papers -CLOUD: Preparing to the cloud	-CLOUD: Pilots at city levels -CLOUD: Legal and regulatory reform	-CLOUD: Whole smart cities on the Cloud
	-IoT: Preparing to the IoT	-IoT: Regulations and procurement	
NICHES of novelties	***Short term (2014)***	***Medium term (2017)***	***Long term (2022)***
Technological change	-CLOUD: SaaS -CLOUD: IaaS	-CLOUD: PaaS	- Higher capacity of broadband networking - Tele-Immersive Environments
	-IoT: Experimental facilities -IoT: Open / linked data	-IoT: M2M in city environments	
Industrial change	-CLOUD: Private and hybrid clouds -CLOUD: Hosting of G city services	-CLOUD: SaaS and PaaS in the main domains of cities	
	-IoT: IPv6 and HTML5	-IoT: Smart gird / smart meters in cities	
Social change	-CLOUD: Pilot city applications in city utilities, districts, and gov.	-CLOUD: Large scale demand of smart city applications and services	
	-IoT: Sensors for city environment alert	-IoT: Embedded city intelligence proof of concept	-IoT: Extended demand for sensor over city networks
Policy change	-CLOUD: Government roadmaps to G services -CLOUD: US reform of IT management	-CLOUD: Standards development and adoption	
	-IoT: China encouraging technologies for IoT	-IoT: FP8 IoT PPP -IoT: Harmonisation of frequency bands	

Table 5-1: Internet Technologies and Smart Cities Roadmap (with focus on Cloud and IoT)

In developing **smart city solutions**, city authorities have to become aware about a number of existing methods for involving the users, which are abundantly described in the literature, such as the Lead User, User Driven Innovation, User Centred Design and User Created Content, and User Co-Creation perspectives. The existence of a new technology stack of "cloud-IoT-linked data" does not guaranty automatically the development of new services based by these technologies. The recommendation is for adopting Living Lab, Open Innovation, and Web 2.0 product development perspectives, which promote a more proactive role of end users and citizens in services innovation, assuring the good coordination between technology offer by vendors and services demand by citizens and cities.

Future Internet technology is a key driver for offering infrastructure, platforms and solutions for smart cities. However they don't assure a higher intelligence and problem solving capability unless they are integrated to a wider architecture of coordination among the physical, institutional, and digital spaces of cities. City authorities and leaders are called to master a series of smart city layers, including (1) infrastructure development combining wired and wireless networks, (2) embedded systems into the physical space of cities, sensors, smart devices and meters, (3) applications for data integration and city functions management, (4) e-services development and provision, (4) innovation ecosystems and user-driven environments for applications and services creation, (5) business models for smart city sustainability and viability, (6) monitoring and measurement scoreboards and methodologies, which offer higher spatial intelligence through their integration and coordination.

Towards Smarter Cities – Strategic Smart City Perspective

Adopting a strategic perspective over the impact of these changes over smart cities can provide meaningful answers to governance challenges. The four pillars listed below can offer a safer way of guiding smart cities within a rapidly changing environment of technologies, societal change, and business models.

The first pillar concerns the development of a sharing and collaboration culture. "Share more - Develop less" is about the exchange of applications among city authorities, the creation of communities of non-trading solutions, sharing and exchanging application software. This goes together with the use of free open source software and participation in FOSS communities. Open source is ideal for city authorities as they don't compete on software and don't create advantages on proprietary software. If existing free software and applications are not available, the closest solution is the cloud. The cloud offers serious cost and maintenance advantages; additionally sharing on cloud-based solutions and data is much easier and effective.

The second pillar is about the development of a forward thinking culture and a medium to long-term perspective. "Look forward" is about the understanding of a ten-year horizon of events, which becomes possible from existing foresight studies [Gylfason 2010]. Watch and monitoring what other communities do, learning from others, foresight and focus groups might reduce the risks of investments. Sustainability over a long term period should also be carefully examined, as well as the assessment of alternative business models for achieving it.

The third pillar is about low-cost solutions. "Spend less", use existing software, re-use software, proceed by small steps and minimize investments is a more safe strategy. Radical innovations and most big things start small. Develop applications from scratch should be the last resort, in case that no other solution is available. Standardisation of solutions will accelerate technology diffusion and learning curves as city administrations become aware of their added value.

Fourth, in developing smart city solutions over city-wide platforms, city authorities have to become aware about a number of existing methods for involving the users, which are abundantly described in the literature, such as the Lead User, User Driven Innovation, User Centred Design and User Created Content, and User Co-Creation perspectives. The existence of a new technology stack of "cloud-IoT-

linked data", which characterise the emerging Internet technologies, does not guaranty automatically the development of new services based by these technologies. The recommendation is for adopting Living Lab, Open Innovation, and Web 2.0 product development perspectives, which promote a more proactive role of end users and citizens in services innovation, assuring the good coordination between technology offer by vendors and services demand by citizens and cities.

Sharing applications, using existing and proven solutions, turning to open source and cloud-based solution, adopting a long perspective over solutions and data, have a strong concern about the sustainability /viability of solutions are milestones for an effective and wise governance of smart cities.

6. Conclusions and Final Remarks

This White Paper has explored the landscape of "smart cities" as environments of open and user driven innovation sustained by Future Internet technologies and services. Smart cities are also seen as environments enabled by advanced ICT infrastructure for testing and validating current Future Internet research and experimentation. Overall, the smart city is built upon a triangle of "City" – "Living Labs" – "Future Internet" components.

Such social and technical infrastructure is one of the key determinants of the future welfare of cities. Other determinants of the welfare of cities are important as well: creative population, infrastructure and institutions for education and innovation, networks of collaboration between businesses and governments, the role of active and demanding citizens, businesses and authorities to push for innovation and quality of services. In this sense, there is a clear analogy to Michael Porter's concept of national competitive advantage: the welfare potential of cities and urban areas depending on factor conditions (human resources, capital, infrastructure, information), demand conditions, related and supporting industries and suppliers, strategy, and government.

The Concept of "Smart City"

Based on a holistic instead of technology merely driven perspective on smart cities we consider necessary to revisit the concept of the Smart City itself. The concept of the smart city that emerges from FIREBALL can be summarized as follows:

> The smart city concept is multi-dimensional. It is a future scenario (what to achieve), even more it is an urban development strategy (how to achieve it). It focuses on how (Internet-related) technologies enhance the lives of citizens. This should not be interpreted as drawing the smart city technology scenario. Rather, the smart city is how citizens are ***shaping*** the city in using this technology, and how citizens are enabled to do so. The smart city is about how ***people are empowered***, through using technology, for contributing to urban change and realizing their ambitions. The smart city provides the conditions and resources for change. In this sense, the smart city is an urban laboratory, an urban innovation ecosystem, a living lab, an ***agent of change***. Much less do we see a smart city in terms of a Ranking. This ranking is a moment in time, a superficial result of underlying changes, not the mechanism of transformation. The smart city is the engine of transformation, a generator of solutions for wicked problems, it is how the city is behaving smart.

We propose the following statements as clarifications to this concept:

- The Smart City concept is useful as a mobilizing concept. It is bridging between and bringing together various professional communities (urban development, innovation management, Internet technology, local policy). However the Smart City concept is not a reality: it is a future scenario, and even more an urban development strategy of how citizens are shaping the city in a continuous process of development and change.
- There are no easy Smart City "common off the shelf" solutions. The concept of Smart City has been adopted by technological solution providers and city marketing departments to promote the city and new solutions. To date, the smart city concept has been technology push. It has been interpreted mainly from a technology point of view and has inspired predominantly technology driven visions.
- There is a lack of attention (also in most of our Smart City case studies which we studied) to engagement and empowerment of citizens, SMEs and other entities realizing their needs or ambitions, and of how citizens are empowered to participate in urban development and social innovation in general.

- There is a need for much more than now working directly with or for citizens groups, SMEs, local governments, technology providers and other actors to develop, prototype and validate solutions that are really in the interest of cities and their citizens. There is a need to address the important topic of a societal view of smart cities, and to address the new theme of "social innovation". People need tools to be empowered in shaping their urban environment.

Technologies for Smart(er) Cities

We found that the Future Internet domain landscape comprises a great diversity of research streams and related topics for designing alternatives for smart cities. However, most connected and influencing smart cities are the following technology streams:

Networking Technology is about bringing higher broadband capacity with FTTH, 4G LTE and IP Multimedia Systems (IMS) as well as future networking technologies. These will enable the democratization, in terms of reasonable cost for high quality service, of Immersive Digital Environments. Such environments enable, for example, the radical increase of telecommuters (far less people travelling in and out the city), remote diagnosis in healthcare, and web-streaming of cities' events. All these examples would contribute to reduce the level of congestion and wasted time and resources in every situation. Research areas such as Content Centric Networking (CCN) and Ubiquitous Computing are also promising faster processing that would increase the real-time capacity that is vital for mass interactions.

Internet of Things (IoT) is considered as a major research and innovation stream leading to create plenty of service opportunities in interconnecting physical and virtual worlds with a huge amount of electronic devices distributed in houses, vehicles, streets, buildings and many other public environments. These technologies open up a new innovation technology paradigm of embedded spatial intelligence cities, emerging from cloud computing, embedded smart sensors and devices, and open data.

Cloud computing and its impact on smart city solutions has been discussed in many foresight studies and reports. While in the short-term, cloud computing will be delivered by large commercial clouds, government G-clouds are promising models for (larger) cities, creating urban clouds that reduce IT costs, and providing platforms for small business applications and e-services. Cloud computing is opening new possibilities in virtualisation of physical spaces and their substitution by digital ones. Extremely important is the expected standardisation of smart city systems, platforms, and applications, which is necessary to provide on-demand self services. Standardisation will accelerate technology diffusion and learning curves as city administrations and their IT departments will become aware of proven solutions for the main districts and sectors of the city.

Embedded networks of sensors and devices into the physical space of cities are expected advancing further the capabilities created by web 2.0 applications, social media and crowdsourcing. A real-time spatial intelligence is emerging having a direct impact on the services cities offer to their citizens. Collective intelligence and social media has been a major driver of spatial intelligence of cities. Social media have offered the technology layer for organizing collective intelligence with crowdsourcing platforms, mashups, web-collaboration, and other means of collaborative problem-solving. Now, the turn to embedded systems highlight another route of spatial intelligence based on location accurate and real-time information. Smart cities with instrumentation and interconnection of mobile devices and sensors can collect and analyse data and improve the ability to forecast and manage urban flows, thus push city intelligence forward.

Cloud computing and the IoT are fundamental layers of **ubiquitous connectivity** on which stands a layer of open public data and advanced analytics for fast reaction and real-time decisions. The open data trends have expended to government data and many public agencies are providing access to datasets stimulating the creation of applications for information retrieval and decision making. Open

data from various sources, government, sensors, citizens and businesses, and linked data with semantic technologies offer opportunities for advanced analytics and intelligence to detect patterns, generate alerts, visualise information and predict trends.

However, for cities and their citizens and businesses, the Future Internet is an abstract concept and far away from reality. They are interested mostly in applicable solutions and in participating in planning and decision making, less in longer term technology innovation. However to some extent citizens and businesses are willing to participate in pilots aiming to develop and validate such solutions.

The urban ecosystem comprises different innovation and engineering cycles with different objectives, resources, timelines and different priorities from the side of the actors. These cycles should be distinguished although they are interacting, and should be monitored and gardened.

The longer term innovation cycle is represented by experimenting on new Internet technologies. Actors (often mentioned "users" however this is confusing) involved are mostly research institutes and larger technology companies. End-user participation to this cycle is generally not realistic. End-users may only participate to this cycle if there is a clear benefit for them. Targeted end-users will be the "lead innovators" within companies or wider professional communities.

The shorter time innovation cycle aims to develop, prototype and validate applications and solutions. Service innovation is a key goal of this cycle. In doing so these cycles will contribute to urban development and social innovation. End-user participation is natural for this cycle, but might not always be feasible. Targeted end-users may include lead innovators within professional communities, but also active citizens and businesses in domains such as energy efficiency, healthcare, government services and other.

Urban Innovation Ecosystems and Living Labs

The technology landscape represents a space of opportunities which must be aligned with the needs and ambitions of citizens and cities within urban innovation ecosystems. FIREBALL started with the perspective that developing towards a smart city needs three ingredients: cities, user-driven innovation environments such as living labs, and Future Internet technologies and related testbeds. Communities or stakeholders within the "urban value system" related to these ingredients fulfill different roles in making a smart city :

1. **Local governments** set challenges of competitiveness, inclusion and sustainability, and develop and implement policies for urban development and orchestrate the planning and decision process. Policy instruments such as pre-commercial procurement contribute to pushing innovation.
2. **Citizens and businesses** have an immediate interest in shaping their living and working environment. Representing the demand side, they increasingly organize themselves in grassroots citizen interest groups or professional communities.
3. **Living labs** act as generators of ideas and innovative solutions through open innovation, and as "arenas" bringing together different actors from both demand and supply side in the relevant value networks. It is a fundamental trend of smart cities that solutions have to be defined and implemented with the involvement of citizens, as consumers and users, as well as large enterprises and SMEs both acting as advanced users and suppliers, together with researchers and policy makers.
4. **Research and technology communities** such as research institutes / laboratories offer technological know-how as well as facilities for technology testing and for the evaluation of user experience enrichment and level of engagement.

The smart city cases undertaken in the framework of FIREBALL illustrate the opportunities for intensive collaboration among the various stakeholders and citizens involved in building the smart city innovation ecosystem, and several interesting practical examples are provided.

The Living Labs (or Innovation Labs, Urban Labs) concept represents a powerful approach to the organisation of user-driven open innovation environments. As a concept applied to smart cities, it embodies open business models of collaboration between citizens, enterprises and local governments, and the willingness of all parties -including citizens and SMEs - to engage actively in innovation. The Living Lab concept also provides a methodology and a model for organising specific innovation programmes/projects and conducting innovation experiments. Both aspects are important: living labs 1) *shaping* and 2) *operating* the urban innovation ecosystem.

The concept of open and user-driven innovation looks well positioned to serve as a mediating, exploratory and participative playground combining Future Internet push and urban policy pull in demand-driven cycles of experimentation and innovation. Living Lab-driven innovation ecosystems may evolve to constitute the core of "4P" (Public-Private-People-Partnership) ecosystems providing opportunities to citizens and businesses to co-create, explore, experiment and validate innovative scenarios based on technology platforms such as Future Internet experimental facilities involving SMEs and large companies as well as stakeholders from different disciplines.

However, in order to fulfil their promise as a key element of urban innovation ecosystems, many living labs should become mature and professional in terms of their "business model" and "business process management", service offering and capabilities to create networks and orchestrate collaboration among a wide diversity of actors (i.e. SMEs, citizen user groups, larger companies, policy actors, research laboratories).

Common Access to Resources and Facilities

Common resources for research and innovation include testbeds, Living Lab facilities and services, access to user communities, technologies and know-how, open data and more. Such common resources can be potentially shared in open innovation environments. Several projects discussed in this paper provide evidence of collaboration models for sharing resources such as the use of Living Lab facilities and methods in experimenting on Future Internet technologies and the use of Living Lab methodologies for implementing innovation policies of cities.

The potential types and structures of these collaboration frameworks and the concrete issues to be resolved in sharing research and innovation resources, such as governance, ownership, access, transferability and interoperability, need further examination and also need development and piloting in future pilot projects.

The current experimentation and innovation approaches used in some of the FIRE and Living Lab projects should be studied more closely in order to develop concrete examples of resource sharing opportunities. Initial examples of resource sharing appear in making user communities available for joint use with Future Internet facilities (e.g. the TEFIS project), and in making accessible Future Internet facilities for developing and validating IoT-based service concepts and applications through Living Labs approaches for smart cities (e.g. the SmartSantander and ELLIOT projects).

The Future Internet constitutes both a key technology domain and a complex societal phenomenon with an underlining huge expectation in terms of job creation and well-being. Effective user driven processes of innovation, shaping and application of Future Internet technologies in business and society are crucial for achieving socio-economic benefits. A key requirement emphasised in this paper is how, within an environment of open innovation in smart cities and governed by cooperation frameworks, the diverse set of resources or assets that constitutes the "engine" of ongoing research and innovation cycles can be made accessible for users and developers for co-creating innovative services.

Connected Cities, Connected Infrastructures

FIREBALL has explored the concept of "common assets", a view of making accessible and sharing smart city resources such as network infrastructures, technologies, applications, know-how and services. The cases which we have elaborated mainly focus on making available these resources on a geographical area (urban environment, region). There is a need to explore the concept of connected cities in this respect, addressing issues such as how different cities in a region or in different regions can get access to the services provided by assets or resources hosted elsewhere. And, what kind of new services can be foreseen building on this concept of common, geographically distributed assets, e.g. testbed and living labs services for innovators in smart cities. There already exist examples of emerging bodies integrating a technology testbed and a Living lab, such as ImaginLab that is an open platform dedicated to experimentation, from integration and interoperability testing to usability evaluation for new products and services on fixed and mobile networks (FTTH and 4G LTE).

To some extent, projects dedicated to Future Internet experimentation and dedicated to Living Labs innovation may interact and even work together in hybrid models of which we have provided examples. Such models could be dynamically evolving over time, as "organisms" constituting the infrastructure of urban and regional innovation ecosystems.

Future Internet and Living Labs normally represent different cycles of innovation (see above) but there might be concrete interfaces and interactions. Concrete, practice-oriented projects should be elaborated in order to gain more insight and experience regarding the benefits and synergies, and regarding the integration of testbed and living lab methodologies.

Based on these thoughts, a future vision for 2020 very well might be that Internet infrastructures, services and applications will form the **backbone of connected regional and urban, even transnational innovation ecosystems**, fostering co-creative innovation and new business creation. This backbone connects the resources and enables the provision of and access to services independent of location (e.g. crowdservicing).

Towards Smart(er) Cities

An important part of the FIREBALL effort focused on describing how cities in Europe are transforming their processes for becoming smarter (more intelligent) cities. This was done in composing showcases that illustrate smart environments, applications and solutions and through surveys and case studies in cities like Thessaloniki, Manchester, Helsinki, Lisbon, Oulu and Barcelona. Altogether, they illustrate both top down planning and bottom-up initiatives for the making of smart urban environments.

However, in the smart city initiatives studied, the socio-economic impact of these initiatives should become more evident. Throughout Europe there is a need for advanced monitoring methodologies and benchmarking scoreboards (such as the EU Innovation Scoreboard) to assess effectively and comparatively costs and benefits from investments in broadband infrastructure in cities, sensor networks, smart city platforms, e-services, and user-driven innovation initiatives over this tangible and intangible infrastructure. There should be also concrete methods and indicators to evaluate the enrichment of user experience, the level of people/citizens engagement and the resulting co-created value and empowerment of citizens, as innovation is all about empowering humans.

Actors involved, such as represented by FIRE, Living Labs and Smart Cities, and including businesses and local authorities, should develop terms of sustainable 4P-based collaboration to realize this vision. They should actively form alliances and partnership agreements. Such collaboration agreements should be based on concrete projects targeting cities' societal challenges in particular areas such as healthcare, social innovation, job creation, wellbeing, environmental issues, such as resources consumption (e.g. energy and water management,) and less pollution, reduction of

congestion (e.g. smart mobility and optimised transportation) and result in concrete co-created value.

There is a need to link living labs, future internet research and commercial potential in order to create business impact and entrepreneurship. The recently initiated NSF I-Corps program is a good example, as it brings together the technological, entrepreneurial and business know-how to accelerate the exploitation of technologies. Another recent initiative is the Canadian Digital Accelerator for Innovation and Research (DAIR), initiated by CANARIE, which is a "digital sandbox" where high-tech innovators – SMEs - can rapidly design, validate, prototype and demonstrate new technologies for world markets[10]. Both Living Labs and FIRE need to increasingly engage industrial actors and SMEs into the development of technologies and facilities, in order to tackle the identified challenges of knowledge transfer from research to business and research based entrepreneurship. This requires new forms of partnerships and even "business models" underpinning future sustainability.

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[10] See: www.canarie.ca/en/dair. This program has started December 2011.

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