FRAMEWORK PROGRAMME 7,
THEME 3, OBJECTIVE 1.6
ICT – INFORMATION AND COMMUNICATION TECHNOLOGIES

COORDINATING ACTION

FIREBALL

FP7-ICT-2009-5

D2.1 – LANDSCAPE AND ROADMAP OF FUTURE INTERNET AND SMART CITIES

STATUS: VERSION: DRAFT, SAVED: 17 NOVEMBER 2010

This report presents a first overview of the landscape of Smart Cities as innovation systems for Future Internet research. The different approaches of three communities and their linkages are being examined: smart cities, future internet research and experimentation, and open and user driven innovation in living labs. On the basis of our analysis, first principles for collaboration among the three communities are proposed, and some initial examples given.

ABOUT FIREBALL

The over-all objective of the FIREBALL project is to coordinate and align methodologies and approaches in the domains of Future Internet (FI) research and experimentation testbeds and user driven open innovation towards successful innovation in smart city environments.

In doing so, and in covering the whole FI research and innovation value chain driven by smart cities being the users of the FI, FIREBALL aims to establish effective forms of cooperation across the FI innovation value chain, creating synergies and cooperation practices among different research and innovation communities related to the FI.

www.fireball4smartcities.eu

ATTRIBUTES OF THIS OBJECT

Project Type	Coordinating Action
Project name	FIREBALL
Project ID	FP7-ICT-2009-5
Deliverable	D2.1 (M6)
Deliverable name	Landscape and Roadmap of Future Internet and Smart Cities
Work package	WP2, Task 2.1
Object type	
Object title	
Version	0.7
Status	Draft
Responsible org.	ESoCE Net
Creators	Hans Schaffers, ESoCE Net (Ed.) Annika Sällström, CDT Nicos Komninos, URENIO Panagiotis Tsarchopoulos, URENIO Bernard Senach, INRIA Brigitte Trousse, INRIA Marc Pallot, INRIA Hendrik Hielkema, CKIR
Submitted	16.11.2010
Approved date	
Approved by	<receiving EC person>
Dissemination	

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1 INTRODUCTION

1.1 OBJECTIVE AND CONTEXT OF THIS REPORT

Smart cities can be considered as innovation ecosystems for Future Internet research and experimentation. The aim of this report is to present an overview of the emerging landscape of user driven open innovation in the domain of the Future Internet applied to the context of smart cities. The landscape is grounded in the linkages between three constituencies: Future Internet research and experimentation, open and user driven innovation ecosystems, and smart cities policy. We explore the implications for user driven open innovation of Future Internet-enabled services applied towards the Smart City development.

This study forms part of our attempt within FIREBALL to bring together three different constituencies: those working on user driven open innovation, on the Future-Internet, and on smart cities. We are contributing to building a dialogue between these communities and support new ways of collaboration. The main goal consists to stimulate collaborative innovation on Future-internet enabled services and advanced applications for smart cities, in an environment of user driven open innovation ecosystems. It is intended to prepare future joint initiatives such as research and pilot projects. We identify synergies and complementarities in the different technical and methodological approaches, pursuing the evolution towards integrated and holistic strategies and approaches for cities innovation, that are appropriate to empower Smart Cities based on Future Internet services.

The emerging landscape includes different approaches to developing, testing, validating and mobilizing user engagement related to Future Internet based innovation for Smart cities. This landscape and how it evolves over time will be described and evaluated, covering various aspects including stakeholder networks, methodologies and approaches, and current practices as well as future visions. Existing and future synergies, integration opportunities and cooperation prospects will be identified. In close cooperation with Cities, Future Internet and Living Labs partners within the consortium, the different elements will be identified that constitute a coherent vision and action plan for near-future Smart City innovation strategies, based on the needs of Smart Cities, on Future Internet advancements as well as evolving living labs methodologies. During the FIREBALL project, experiences and results will be gathered in the form of a roadmap, based on analysis of needs, opportunities and gaps, to benefit a wide scale implementation of the methodologies and concepts elaborated.

1.2 APPROACH

The approach of this report is to explore the different elements of the emerging landscape. This report is to be considered as the first edition of two next updated reports that will provide more in-depth insights and results (to be published in May 2011 and, as final report, May 2012). The different elements and aspects that are being explored include: Trends and developments in smart cities, open innovation and future Internet; Common synergetic elements of collaborative innovation across the three areas, and Initial example collaboration models. The "content" of these explorations leads to an initial "roadmap" which is meant to understand the implications of the emerging landscape.

During our work within the period from May 2010 – October 2010, we established close relationships with the constituencies involved and we are building joint activities with, in particular:

- ENOLL: European Network of Living Labs, www.enoll.org

- FIA (Future Internet Assembly), www.future-internet.eu
- Eurocities, as a platform for Smart Cities innovation, www.eurocities.eu
- Related projects within the CIP ICT-PSP and FP7-ICT programmes (e.g. SmartSantander, FIRESTATION and several others).

As a result of these exchanges and bridging activities we mention the following activities:

- Participation in ICT 2010 to contribute to joint sessions with the FIA and Living Labs communities.
- Participation in the FISA (Future Internet Support Actions) Joint Roadmap activity, which is ongoing from 2010 – 2011 and will influence FP8.
- Organising a joint workshop on Future Internet and Smart Cities during the Future Internet week, Ghent, December 2010.
- Organising a Living Labs day during the Future Internet Week, Ghent, December 2010.
- Contributing a chapter on Smart Cities and Future Internet in the FIA 2011 book, to be published in March 2011.
- Starting a Smart Cities survey, in collaboration with Eurocities.

1.3 OVERVIEW OF THIS REPORT

In section 2 an initial overview of the landscape is provided. Sections 3, 4 and 5 respectively present more focused overviews of Smart Cities, Future Internet and Living Labs activities. Elements of the descriptions are: state of the play in each of the areas, trends and developments, and opportunities to build bridges with other communities. In Section 6 a first and preliminary attempt is presented to integrate the different elements into a coherent roadmap. Section 7 brings together some of the most important elements to build a vision on joint collaboration. Section 8 summarizes the main points and provides an outlook to the next phase of work.

2 SMART CITIES AS OPEN INNOVATION ECOSYSTEMS FOR THE FUTURE INTERNET

The terms "Smart Cities" or "Intelligent Cities" are often being used to denote the use of digital spaces and advanced ICTs to enhance the activities, services and economic development potential of cities (see section 3 for further detail). The Future Internet is a concept which represents a promise of advanced ICT infrastructure to enable services, applications and business models benefiting citizens and enterprises in the future. User driven open innovation represents a concept of an innovation ecosystem characterized by real-life experimentations and cooperation among all stakeholders including users across the value chain. It requires an active engagement of end-users of ICT-based innovations, such as citizens and businesses, to initiate and shape those innovations. Our interest is in the innovation ecosystem playground of cities constituted by these developments.

Clearly, there is a potentially beneficial relationship between the three concepts (Future Internet, Living Lab and Smart Cities) which needs further examination and also experimentation, in future pilot projects. Such relationship may lead to extended or even new models of collaboration among the involved constituencies. Some promising evidence of collaboration models is already available, such as the use of living lab concepts for innovation policy and the use of technical methodologies to stimulate innovation and socio-economic development in cities and regions.

Other aspects of the collaboration "triangle" are more demanding, for example how living lab facilities and Future Internet (FI) testbeds could operate together, or how the more technology push oriented Future Internet initiatives could benefit the socio-economic objectives of cities. Regarding the first aspect, one could be claiming that service or application scenarios could be explored within Living Lab facilities and experimented within FI testbeds. However, it would require that FI testbeds will be sufficiently flexible to accommodate different service or application scenarios co-created by users and necessary stakeholders such as testbeds designers. As for the second aspect, it could be argued that while FI initiatives bring the technology push, smart cities bring the application pull. As a potential outcome, it could be expected that the confrontation in between technology push and application pull will result in innovative services or applications with a higher potential of adoption by user/citizen communities.

It is also unclear in what way there might be a case for "direct" collaboration process between living labs, Future Internet facilities and smart cities, in terms of results of one activity to be used in the other. The activities mentioned comprise different time horizons, objectives and stakeholder settings. A different and more realistic vision on collaboration models could be built on the concept of innovation system of cities. Complementary and jointly developed "assets" or "resources" together with forms of strategic management of innovation stimulate the creation and transition of knowledge flows for innovation in business, and eventually for socio-economic development of cities and regions.

The key driver of collaboration can be seen in an extended, holistic view of what constitutes a smart city. A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance [1]. It is important to view the concept of smart city as a promise or ambition, not yet as a reality.

The same applies to the Future Internet. The current activities in many cities to deploy wireless of fiber-based broadband networks and experiment on ICT-based innovations demonstrate a willingness to exploit the opportunities of such infrastructure. There are many examples of interesting pilot experimentations in areas such as health and care, energy and e-government. However over-all we are still far away from scaling-up such pilots and deploying wide-scale applications to achieve real economic and social benefits in cities and regions.

The concept of "living labs" as a model of user driven open innovation in real-life is also promising as it is based on extended forms of collaboration and engagement of users in the co-creation of innovative scenarios. However, as it comes to concrete evidences, this concept is not yet an operational reality. There exist still only few mature examples of what truly could be called "living labs". However, during the last years, a lot of experimentation on this concept has been going on which shows a rich diversity of concepts, approaches, methodologies and practices.

The initial view that we propose regarding the landscape of Smart Cities, Future Internet and Living Labs, and their associated collaboration models, which we will explore in this report, consists of the following elements.

1) Future Internet research and experimentation, supported by experimental testbeds, creates the future ICT-infrastructure. This is mostly oriented to testing of technologies and services. In many ways, these technologies and services form the foundation of advanced future applications (healthcare, creative media, e-government, smart energy, domotics, assisted living).

2) Smart cities will be built upon modern ICT infrastructure, as one of the determinants of cities' welfare. Other determinants of cities' welfare will be important as well: the infrastructures for education and innovation, the networks between businesses and governments, the existence of demanding citizens and businesses to push for innovation and quality of services. Here we see a clear analogy to Porter's concept of national competitive advantage: the cities welfare potential.
3) The Living labs concept represents a general view of user driven open innovation ecosystems. 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, in different phases and at different levels (policy – innovation – implementation). The living lab concept should be considered also as a methodology, a model for organizing specific innovation programs, innovation projects and innovation experiments. Whereas the last aspect has gained most attention, both levels are important: shaping and operating the innovation ecosystem.
4) The innovation ecosystem view of living labs should recognize different drivers and origins of innovation and their potential for interaction and synergy. The first is emerging more or less technology push from Future Internet research and experimentation. "Valorization" is the strategy to transform such research and experimentation into business. The second origin is more short term oriented to innovative applications, enabled by ICT-infrastructure, targeting the goal of city development and business creation. This is more in line with living labs thinking. The model of fostering the interactions among these innovation types is two-sided: both top down and bottom up [cf. Nonaka's view of knowledge creating company which has some analogy to cities].

The FIREBALL vision considers smart cities as innovation ecosystems in their own, an arena characterized by open innovation engaging the stakeholders including citizens, where the opportunities of the Future Internet and the needs of citizens and enterprises will be aligned.

Urban value creation system

The concept of "national competitive advantage" developed by Michael Porter, which borrows from the national systems of innovation thinking of Chris Freeman, could be useful as an analogy to the city "value creation system". This is visualized in Fig. 2-1 using Porter's "diamond" model.

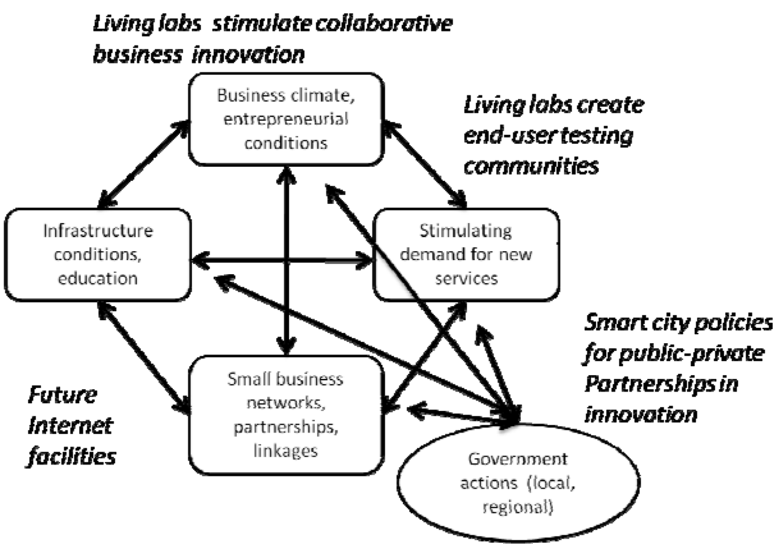


Fig. 2-1 Smart city value creation and innovation system (using Porter's concepts)

The city value creation system can be considered as constituted by four determinants: 1) infrastructure, 2) networks and collaboration, 3) entrepreneurial climate, 4) demand for services (active users). The value creation system is also affected by local governmental actions e.g. towards stimulating the building of networks, the creation of public-private partnerships, and the enhancement of innovative conditions.

Collaboration models in the value creation system

Collaboration models underlying smart cities innovation ecosystems will be multifaceted. One level is public-private partnership in city innovation programs. The second level is collaboration within the innovation ecosystem, among innovation activities, to create synergies and exploit complementarities. The second level falls apart in two distinct collaboration types.

The first type is collaboration **within** the innovation process. The collaboration process model requires one activity to feed into the other. E.g. Future Internet research is testing a context-aware service; this service (software module) feeds into a living lab process to create innovative applications in a user-driven process.

The second type is collaboration **across** distinct research, experimentation and innovation processes. This model of "co-existence" considers different and focused innovation activities which could be demand driven (applications development in user contexts) or technology push (research on Internet technologies) or hybrid forms. The innovation ecosystem of cities in this respect builds on creation and exchange of knowledge, on stimulation of knowledge flows and interactions, less on the innovation process itself.

3 SMART CITIES: STATE OF THE ART AND DEVELOPMENTS

3.1 DEFINITION AND DESCRIPTION

Our starting point is the description of Smart Cities found in Wikipedia (http://en.wikipedia.org/wiki/Smart_city): Urban performance currently depends not only on the city's endowment of hard infrastructure ('physical capital'), but also, and increasingly so, on the availability and quality of knowledge communication and social infrastructure ('intellectual and social capital'). The latter form of capital is decisive for urban competitiveness. It is against this background that the concept of the "smart city" has been introduced as a strategic device to encompass modern urban production factors in a common framework and to highlight the growing importance of Information and Communication Technologies (ICTs), social and environmental capital in profiling the competitiveness of cities. The significance of these two assets - social and environmental capital - itself goes a long way to distinguish smart cities from their more technology-laden counterparts, drawing a clear line between them and what goes under the name of either digital or intelligent cities.

Smart(er) cities has also been used as a marketing concept by companies and by cities.The Smart Cities community can be described on multiple levels. On the one hand, Smart Cities is a concept that attracts attention from many cities. It provides a future image of how cities could look like, in terms of economic development, sustainability, innovation environment etc. This way it inspires city development strategies. Its importance is highlighted by the fact that several cities are working together in Smart City Networks. One of them is Eurocities (www.eurocities.eu) which is a network of 130 large cities in 34 countries. The role of Eurocities network is to prepare common approaches to issues of interest for large cities.

In relation to the Future Internet, their recent policy papers on "Broadband Deployment" (Eurocities, 2009) and on "Cities and innovation in Europe" (Eurocities, 2010) are of high interest. Internationally and outside Europe, several major cities have developed Future Internet policies as well, which exemplifies the potential linkage between Smart Cities and Future Internet.

The terms "Smart City" and 'Intelligent City" have been used with various meanings to denote the use of digital spaces and information and communication technologies to enhance the activities, services, and economic development of cities. The "smart city" literature gives more emphasis on the use of sensors, embedded systems, devices, and mobile phones for creating the digital dimension of cities; while the "intelligent city" literature focuses more on broadband networks and the Internet as medium for organizing the collective intelligence of cities. A common denominator appears to be the well-known "Ambient Intelligence", which is revealed as the historical root. Future Internet research brings those two digital dimensions of the city together envisioning an integrated ICT space of multiple 4G broadband networks, virtualization of infrastructure, RFIDs, smart mobile devices, Web 3.0, semantic web, the Internet of data and things.

Some formal definitions of smart or intelligent city to be found in literature are the following.

MIT Smart Cities Group http://cities.media.mit.edu/

"The new intelligence of cities, resides 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)."

This does not exist in isolation from other urban systems, or connected to them only through human intermediaries. There is a growing web of direct connections to the mechanical and electrical systems of buildings, household appliances, production machinery, process plants, transportation systems, electrical grids and other energy supply networks, water supply and waste removal networks, systems that provide life safety and security, and management systems for just about every imaginable human activity. Furthermore, the cross-connections among these systems, both horizontal and vertical, are growing (Mitchell 2007).

URENIO Research

"The term 'intelligent city' describes a territory (community, district, cluster, city, and city-region) with four main characteristics: (1) a creative population and developed knowledge-intensive activities or clusters of such activities; (2) embedded institutions and routines for cooperation in knowledge creation allowing to acquire, adapt, and advance knowledge and know-how; (3) a developed broadband infrastructure, digital spaces, e-services, and online knowledge management tools; and (4) a proven ability to innovate, manage and resolve problems that appear for the first time, since the capacity to innovate and to manage uncertainty are the critical factors for measuring intelligence." (Komninos 2008).

Intelligent cities are organized as multi-layer territorial systems of innovation, bringing together knowledge-intensive activities, innovation support institutions, and digital communication spaces. These layers reflect both the different dimensions of intelligence (human, collective, artificial) and the deployment of innovation on physical, institutional and digital spaces.

The first layer includes the city's knowledge-intensive activities in manufacturing and services. The population of the city, knowledge workers, and innovative companies are the fundamental elements upon which intelligent cities are constructed. Proximity in physical space is important, integrating enterprises, production units, and service providers into a coherent system. Critical factor at this level is the intellectual capital of the city's population.

The second layer includes institutional mechanisms for knowledge creation and social co-operation in technology and innovation. Characteristic examples are institutions enhancing R&D, strategic intelligence, venture capital financing, technology transfer, and collaborative new product development. These are mechanisms that promote cooperation within the clusters of the city, between different clusters in the city, and between innovation processes taking place on physical and digital space. Critical factors at this level are institutional thickness and collective intelligence of the community.

The third layer includes broadband networks and e-services that enable online cooperation. These tangible and intangible infrastructures create virtual innovation environments based on multimedia tools and interactive technologies, which facilitate different innovation processes from market and technology intelligence to collaborative new product development and process innovation based on transaction-saving technologies. Critical factors at this level are content management, information automation, intelligent agents, virtual networking and web technologies.

European Smart Cities project (http://smart-cities.eu/)

"Smart Cities can be identified (and ranked) along six characteristics: (1) Smart economy (competitiveness), (2) Smart people (social and human capital), (3) Smart governance (participation), (4) Smart mobility (transport and ICT), (5) Smart environments (natural resources), and (6) Smart living (quality of life). A Smart City is a city performing well in a forward-looking way in these six dimensions, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens."

The above perspective was the basis of a more comprehensive entry at Wikipedia Smart City entry: "Smart Cities can be identified (and ranked) along six main axes or dimensions. These axes are: a smart economy; smart mobility; a smart environment; smart people; smart living; and, finally, smart governance. These six axes connect with traditional regional and neoclassical theories of urban growth and development. In particular, the axes are based - respectively - on theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities. A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance." See: http://en.wikipedia.org/wiki/Smart_City.

IBM Smart Planet Initiative
http://www.ibm.com/smarterplanet/us/en/

A major contribution to smart cities is coming from IBM which made this concept a flagship of its business strategy.

"A smarter city is one that uses technology to transform its core systems and optimize the return from largely finite resources. By using resources in a smarter way, it will also boost innovation, a key factor underpinning competitiveness and economic growth. Investment in smarter systems is also a source of sustainable employment. Smarter cities make their systems instrumented, interconnected and intelligent:"

- Instrumentation, or digitization, of a city's system means that the workings of that system are turned into data points and the system is made measurable, with the ability to sense its environment and monitor its performance.
- Interconnection means that different parts of a core system can be joined and "speak" to each other, turning data into information.
- Intelligence refers to the ability to use the information created, model patterns of behavior or likely outcomes and translate them into real knowledge, allowing informed actions. True intelligence is more than just embedding transistors into objects. It's the ability of these things to begin to manage themselves, to make choices and self optimize, and in some cases to learn (IBM Institute for Business Value).

3.2 STATE OF PLAY

A global outlook of cities developing smart and intelligent city strategies is given by the Intelligent Community Forum and the cities selected as best performers globally during the 2002-2010 period (see Table 3-1).

	Asia and Australia	North and South America	Europe
2002	Bangalore, India **Seoul, S. Korea** Singapore	**Calgary, Alberta, CA** Florida, high tech corridor, US LaGrange, Georgia, US	Sunderland, UK
2003-04	Taipei, Taiwan Victoria, Australia Yokosuka, Japan	Spokane, Washington, US Western Valley, N. Scotia, CA	**Glasgow, UK** Sunderland, Tyne & Wear, UK
2005	**Mitaka**, Japan Tianjin, China Singapore	Pirai, Brazil Toronto, Ontario, CA	Issy-les-Moulineux, France Sunderland, Tyne & Wear, UK
2006	**Taipei, Taiwan** Tianjin, China Gagnam District Seoul Ichikawa, Japan	Cleveland, Ohio, US Waterloo, Ontario, CA	Manchester, UK
2007	Gangnam District	Ottawa-Gatineau, Ontario, CA Sunderland, Tyne & Wear, UK **Waterloo, Ontario, CA**	Dundee, Scotland, UK Issy-les-Moulineaux, FR Tallinn, Estonia
2008	**Gagnam District Seoul**	Fredericton, New Brunswick, CA Northeast Ohio, US Westchester, New York, US Winston-Salem, N. Carolina, US	Dundee, Scotland, UK Tallinn, Estonia
2009		Bristol, Virginia, US Fredericton, New Brunswick Moncton, New Brunswick, CA	Eindhoven, Netherlands Issy-les-Moulineaux, FR **Stockholm, Sweden** Tallinn
2010	**Suwon, South Korea**	Arlington County, VA Dublin, Ohio, US Ottawa, Ontario, CA	Dundee, Scotland Eindhoven Tallinn, Estonia

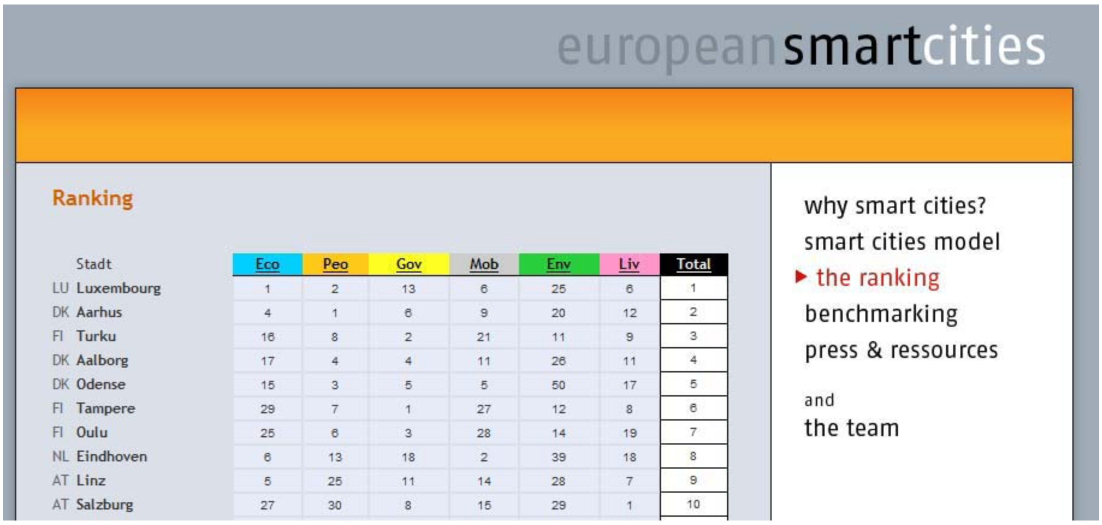
Source: Intelligent Community Forum (http://www.intelligentcommunity.org/)

Table 3-1: Cities developing smart and intelligent city strategies

Apart from the above mentioned cities, some well known cases of European cities implementing smart or intelligent cities strategies are:

- Malta: Smart Island and Smart city projects on the development of ICT industry; the SmartCity@Malta initiative.
- Amsterdam: Amsterdam Smart City projects on energy saving and CO2 reduction. See: www.amsterdamsmartcity.com. Another Dutch city active in smart cities strategy is Groningen.
- Birmingham: the intelligent city programme on smart mobility.

We need to keep in mind the difficulty of ranking cities according to "smartness" indicators. Many rankings exist. For **mid-sized cities**, the European Smart Cities project (www.smart-cities.eu) has used an approach of indicators for "smartness" criteria: smart economy, smart people, smart government, smart mobility, smart environment, smart living (Fig. 3-1).



	Stadt	Eco	Peo	Gov	Mob	Env	Liv	Total
LU	Luxembourg	1	2	13	6	25	6	1
DK	Aarhus	4	1	6	9	20	12	2
FI	Turku	16	8	2	21	11	9	3
DK	Aalborg	17	4	4	11	26	11	4
DK	Odense	15	3	5	5	50	17	5
FI	Tampere	29	7	1	27	12	8	6
FI	Oulu	25	6	3	28	14	19	7
NL	Eindhoven	6	13	18	2	39	18	8
AT	Linz	5	25	11	14	28	7	9
AT	Salzburg	27	30	8	15	29	1	10

Fig. 3-1 Ranking of mid-sized smart cities

Rank	City	Country	Global rank	2010 grade
1	Paris	France	2	1 Nexus
2	Amsterdam	Netherlands	3	1 Nexus
3	Vienna	Austria	4	1 Nexus
4	Frankfurt	Germany	6	1 Nexus
5	Copenhagen	Denmark	8	1 Nexus
6	Lyon	France	9	1 Nexus
7	Hamburg	Germany	10	1 Nexus
8	Berlin	Germany	11	1 Nexus
9	Stuttgart	Germany	13	1 Nexus
10	London	UK	14	1 Nexus
13	Stockholm	Sweden	17	1 Nexus
14	Rome	Italy	21	1 Nexus
16	Barcelona	Spain	26	1 Nexus
21	Helsinki	Finland	37	2 Hub
34	Manchester	UK	58	2 Hub
-	Lisbon	Portugal	-	3 Node

Table 3-2: Innovation Cities Europe index 2010 (Source: 2thinknow)

For "**Innovation Cities**", cities were selected by 2thinknow on basis of factors such as health, wealth, population and geography. These cities were evaluated against more than 100 indicators and data were weighted against global trends. Some of the outcomes are presented in Table 3-2. Other rankings exist for **"Favourite business cities"** (1. London, 2. Paris, 4. Barcelona, 8. Amsterdam, 16. Manchester, 17. Lisbon) and **"Best cities"** (1. Vienna, 13. Amsterdam, 34. Paris, 35. Helsinki, 39. London, 44. Barcelona, 45. Lisbon).

Players in Smart Cities

Important stakeholders comprise local governments and policy makers, as well as industry. Major global ICT companies are involved in the smart city movement:

- IBM with its smarter city / smarter planet initiative: http://www.ibm.com/smarterplanet/us/en/sustainable_cities/ideas/
- Microsoft with applications and platforms for smart mobility: http://www.youtube.com/watch?v=jPHvzU6ZoYE
- CISCO's intelligent urbanization initiative: http://newsroom.cisco.com/dlls/2009/prod_021209c.html

A large number of research labs, academic institutes and research centers are active in the field of smart / intelligent cities, focusing on issues of city economic development, infrastructure management, intelligent environments creation, people participation, and services to citizens. The first academic paper on smart cities was published in 1992 (Gibson, Kozmetsky and Smilor 1992); while the first academic paper on intelligent cities appeared also in 1992 (Laterasse 1992).

An overview of smart and intelligent cities from the perspectives of concept, strategy, technology and applications is presented in Table 3-1.

3.3 TRENDS AND DEVELOPMENTS

From a Smart Cities perspective of urban development, the key drivers towards Future Internet Open Innovation are:

- Socio-economic ambitions of large cities and urban areas (but also strategies for city marketing)
- Need for connectedness (cities – rural areas – regions)
- Broadband deployment experiences, need for applications pull after the infrastructure and technology push. Need to create experimentation environments to stimulate innovation, driving network development as well.
- Impact of Internet infrastructure on business attractiveness of cities
- Need to create open innovation environments to attract business and knowledge centres

Smart Cities represent the evolving need for infrastructures at several levels: innovation infrastructure (networks of collaboration, experimental facilities, research and test centres etc), broadband Internet infrastructure (networks, services). Smart Cities are the "user" of future Internet infrastructure and applications. Smart Cities are the beneficiary of open innovation environments. Naturally, Smart Cities will be the key driver of living labs (user driven open innovation) approaches.

CONCEPT	**GENESIS** **Origins / creation forces** 1. A digital space over the urban agglomeration and its regulation / urban planning 2. Innovation economy, systems of innovation, global innovation systems / end-users involvement to innovation	**CONCEPT** **Different meanings** • DIGITAL cities: Virtual representation of cities • CYBER cities: governance / control • SMART cities: Sensors / city space UI • INTELLIGENT cities: o Intelligent innovation ecosystems o Intelligent environments o Intelligent communities	**STRUCTURE** • **Layer 1**: Agglomeration, clusters, people, **mix** of activities: HUMAN INTELLIGENCE • **Layer 2**: Institutions, regulation, innovation system: COLLECTIVE INTELLIGENCE • **Layer 3**: Virtual environments - intelligence, learning, web-collaboration, ARTIFICIAL INTEL.	**ADDED VALUE** 1. **More innovative cities:** - Global suppliers and markets - New products based on Crowdsourcing - Cost reduction by e-delivery 2. **Infrastructure cost reduction :** e-services for traffic, energy, water, environment, safety 3. **Citizens:** Democracy, e-gov,
STRATEGY	**CASES: INTELLIGENT / SMART CITIES** • ASIA: Singapore iN15, Taipei, Cyberport, Seoul –Gagnam, Media city, Malaysia MSC Songdo, • USA: Florida, Cleveland, Waterloo • EU: Manchester, Glasgow, Issy, Tallin, Arabianranta, Stockholm, Malta, Zaragoza, Amsterdam	**CITY STRATEGIES** Major approaches of building intelligent / smart cities: • Sector-based strategies • Cluster or District-based strategies • Large-scale emerging intelligent cities / multiple cores and sectors • Infrastructure / utilities focus	**POLICY ORIENTATIONS / PLANNING** • INTELLIGENT COMMUNITY FORUM • EU Living Labs • EU smart cities • Smart cities for innovation – CIP • Multinationals: IBM – MS – CISCO	**MEASUREMENT** **Input indicators:** 1. Population education, skills, 2. Knowledge – innovation institutions, 3. Broadband - Virtual environments - Services **Output indicators:** Innovation performance
TECHNOLOGY	**INTELLIGENCE** • OLAP • BUSINESS/ CLUSTER INTELLIGENCE • DATA MINING • BENCHMARKING • COLLECTIVE INTEL – PYTHON	**CONTENT MANAGEMENT SYSTEMS** • JOOMLA • WORD PRESS • WIKIS • MASHUPS	**COLLABORATION WEB** • CO-DESING TOOLS • VIRTUAL COLLABORATION • WEB 2.0 NPD • CROWDSOURCING	**VISUALISATION** • WEB DESIGN – PHP • PANORAMA FACTORY • GOOGLE 3D • 3D STUDIO • TAGWHAT - AUGMENTED REAL
APPLICATIONS	**MAJOR DOMAINS** **Innovation economy**: **activity sectors / city districts**: (1) industrial, (2) services (3) commerce, (4) employment, (4) entrepreneurship, (5) company incubation **Smart infrastructure:** energy, water, environment, traffic, safety **Governance:** e-services to citizens, decision making, e-democracy,	**BUILDING BLOCKS** **Physical-virtual Knowledge functions** Building blocks for all applications 1. **Intelligence**: strategic, BI, Cluster 2. **Learning** - Technology transfer 3. **Innovation** – Collaborative New Product Development 4. **Promotion - e-Marketplace places** – Global dissemination	**APPLICATIONS** (1) Smart industry clusters (2) Intel university campuses (3) Smart ports / airport cities (4) Smart technology parks / incubator (5) Smart Central Business Districts (6) Virtual city tours / e-guides (7) Energy saving districts (8) Urban traffic management (9) Environmental monitoring / alert (10) Safety to public space (11) e-gov / e-city planning	

Table 3-3: Smart and intelligent cities overview

There seems to be a new interest in fiber networks deployment (FTTH)[1]. Internet has become mainstream, and bandwidth needs have increased. An important constraint is that a large part of European homes is still connected with copper loops of 1 km or more. Due to this fact, bandwidth is still constrained and higher bandwidths requires fiber. Fiber rollout will play an important role in next generation access infrastructure. Different financial models need to be developed, and also regulatory issues need to be resolved in order to push this development. Open innovation systems will be critical to align the interests of different players involved (telecoms, governments, universities, application providers, sectors in the economy and society).

One example is the Cities Network (Stedenlink) in the Netherlands, which has developed and actively promoted strategies to accelerate fiber optic deployment based on geographical bundling of demand for broadband services. Recently, the Task Force Next Generation Networks has identified different options for fiber rollout and has studied different financial models. The support of provinces, cities and housing cooperations and the financial model is crucial for success. Promoting the Future Internet and Open Innovation should be grounded in these types of initiatives that already have a strong level of support from cities and provinces. The Eurocities document on Broadband policy (Eurocities, 2010) mentions several city-level broadband deployment initiatives in Europe. Here, we see the need to align policies and initiatives at different levels in order to create synergies and learning effects: city and province, national, and EU.

3.4 LINKAGES ACROSS THE COMMUNITIES

First we address the key actors within the Smart City community. Thereafter we explore the linkages between the smart City community and two other communities: Future Internet and Living Labs.

The Smart City community includes three distinct groups of organisations: (1) cities developing smart / intelligent city strategies, (2) large companies developing platforms and applications for smart cities, and (3) research labs, centres and experts performing research on the subject.

Interlinkages with Future Internet, Living Labs

Large cities have developed policies regarding economic development in relation to broadband deployment and open innovation. The living labs concept has also been endorsed by many cities, through the European Network of Living Labs. Some examples of city-level policies regarding living labs are the following:

- Helsinki: living labs projects e.g. smart urban spaces. See also Forum Virium (www.forumvirium.fi).
- Greater Paris
- Amsterdam: Amsterdam Innovation Motor, Amsterdam Smart Cities
- Barcelona
- Manchester: policies towards urban planning and connected cities. Creating environments for Open Innovation, driven by the living labs concept.

[1] McKinsey (2010): Creating a Fiber Future. See also: OECD (2009): Network Development in Support of Innovation and User Needs.

Smart City has now become an important topic in European programmes for research and innovation (INTERREG, FP6 Intelcities, FP7, CIP ICT-PSP Pilots on Smart Cities e.g. related to energy management, sustainable development). Through creating a network of Smart Cities and linking to ENoLL, Eurocities and also ERRIN (regions), a key element of the emerging landscape will be available for participation in Future Internet and Open Innovation PPP initiatives.

Becoming part of new networks of cooperation opportunities is the key driver of this development. The Smart Cities community will prepare and enrich Future Internet and Open Innovation policies at city level. They will represent the user base and actively involved in developing the innovation ecosystem at city and regions level. They also will prepare deployment strategies of fiber optic networks and broadband advanced pilots.

The Future Internet community e.g. represented by FIA collects the main business, technological and research players. These are also playing an important role in new initiatives such as Future Internet PPP. In order to succeed these initiatives need collaboration with Smart Cities to create experimentation testbeds and large-scale pilots.

The living labs community naturally is close to the smart cities network. However, living labs must become more mature in terms of methodologies, experimental facilities and large-scale pilots. Several initiatives at national and EU-funded level are working towards this goal.

The key vision could be to create interconnected facilities based on commonly shared assets (facilities, methods, technologies, know-how, experts). This could take point of departure in the vision of interconnected cities. However also art cities and regions level we need to create interconnected facilities to support the creation of regional networks of innovation. E.g. a living lab initiative working together with experimental facilities of companies and knowledge centers. The challenge is to create open networks of knowledge and experimentation. One example could be in energy management and sustainable development in smart cities; another in regionally organised healthcare, and in learning and education.

3.5 EXPLOITING THE LINKAGES

Some opportunities to exploit the real and potential linkages between Smart Cities, Living Labs, Future Internet are the following:

- Create field lab initiatives in cities and regions
- Create open innovation environments favorable for business participation
- Align funding opportunities at city, regions and EU level to establish open testbeds
- Develop concrete pilot ideas for open testbeds and open innovation ecosystems in sectoral domains such as energy, health, education and learning
- Resolve technical issues related to network architectures, interoperability

Topics to address include the creation of experimentation facilities for open innovation, the management of common resources and assets embodied in such facilities, and how to arrange access to common assets, IPR issues, and public-private partnership creation.

Smart cities and Future Internet linkages

Future Internet research community opens a new agenda for smart / intelligent cities. Today most platforms and applications for smart cities rely on broadband networks and a set of content / data elaboration technologies, such as programming languages, mainly Java and Python, OLAP, data bases and data mining, content management systems, and visualization technologies. Future Internet research extends this technological base with the Web evolution towards Web 3.0, future eBrowsers, Web as a Platform, HTML 5.0, Cloud Computing, Internet of things, RFIDs, Internet of Data and Services. Smart cities are testbed for these emerging technologies and experimentation with multiple devices and systems.

Within the recent Call 4 of the CIP ICT-PSP programme, on open innovation for smart cities, the Peripheria project (RFID for smart societal services) is related to the Future Internet.

Smart cities and Living Labs linkages

Within the framework of smart cities, Living Lab ecosystems provide the basis for innovation and economic development enabling the participation of the population in the design and development of new products and services. Innovation ecosystems based on a Living Lab participatory processes combine both the strengths of collective intelligence of participants and the mediating role of ICTs in organising global value chains of suppliers and customers. Living labs and participatory open innovation ecosystems offer the economic base of smart cities.

Several cities, and also Eurocities, have developed visions and strategies towards Future Internet Open Innovation. Many cities are involved in broadband deployment and applications pilots (e.g. citizen participation, energy efficiency, content distribution etc). Also of relevance is ERRIN (www.errin.eu/en/) which is the European Regions for Research and Innovation Network of 70 regions in Brussels.

Priorities for Knowledge Society Forum, which is part of Eurocities and has 160 cities involved, are (see D. Carter, 2010):

- Next generation Broadband: fibre networks deployment, applications that could develop across next generation open networks (eHealth, eLearning, eContent, IPTV etc)
- eGOV 2.0, based on the use of social media
- Energy efficiency (towards low carbon economies, supporting behavioral changes in cities to reduce emissions and adaptive to climate change)
- E-Inclusion (tackling digital divides)
- mGOV, mobile applications.

One example of a Smart Cities vision is Manchester. They lead a group of cities within the Knowledge Society Forum (formerly Telecities) focusing on Urban policies on digital innovation and sustainable growth. One of the central elements of this work is to translate principles of physical planning (land use, built environment, physical infrastructures) into the digital world. There is a need for “Digital masterplans” and “digital design guides” to accelerate the development of digital infrastructures, applications and services towards “Connected Cities”. The second element is to create a dynamic environment for open innovation and RTD, building on experience developed by the Living Labs community. The planned Connected Cities should provide the opportunities for new open innovation testbeds that allow mass deployment of new applications and services which should support e-inclusion and e-sustainability.

Broadband in city development

A recent paper of Eurocities (2010) discusses the role of broadband in city development policies. The paper argues that within our knowledge economy, a capable and future proof communication infrastructure is already crucial to a city's economic success and will be even more so in the coming decades. This paper makes the case for the role broadband can play in supporting cities to drive a European economy that is sustainable, inclusive and globally competitive.

It is believed that networks must be based on open access principles, be unbounded scalable & symmetric, be affordable, widely available and use fibre technology. The potential for broadband in cities has to be seen in the context of European policy and legislation, which provides the framework for cities to participate in network roll-out. A number of options exist under the current framework, however cities are still usually categorised as 'black areas', where the public sector should not invest in network roll-out. Nevertheless, there are a number of scenarios in which a case could be made for public intervention in network roll out at the city level, based on examples of current city activities. These include intervention in the case of market failure, providing broadband as a service of general interest, implementing wider public policy such as social inclusion, improving the competitiveness of a place and stimulating local innovation. A number of city examples are used to illustrate these scenarios.

Smart City projects in CIP ICT-PSP

The European Commission nhas strongly pursued the view that cities offer excellent infrastructure for Internet research and innovation. Broadband infrastructure is available, as well as active local research labs, efficient innovation ecosystems, and service infrastructures. A recent Call on open innovation in smart cities in the CIP ICT-PSP program has resulted in several smart city pilots exploring the role of user driven open innovation (starting end of 2010):

- Smart Islands: smart transport, leisure, forest fire fighting, retailing.
- EPIC: Smart City vision. Service catalogue: relocation, urban planning, environment
- Life 2.0: new services for elderly.
- People: basic urban infrastructure.
- Open Cities: open innovation for public sector in cities.
- Peripheria: RFID for smart societal services.
- SmartiP: smart engagement, environment and mobility (Open Data, citizens as sensors, social (data) networking.

Of these projects, Peripheria seems the project mostly related to Future Internet issues as well (Internet of Things).

Also a number of other piloting projects in the CIP ICT-PSP are strongly related to smart cities issues, for example in areas such as health, e-government and energy. Examples are:

- Save Energy (ICT and energy efficiency)
- Apollon (Advanced pilots of Living Labs operating in cross-boundary networks)
- Best Energy (built environment sustainability and technology in energy)
- FREILOT (urban freight energy efficiency pilot)
- HosPilot (intelligent energy control in hospitals)
- In-Time (intelligent and efficient travel management for European cities)

- epSOS (smart open services; open health initiative for a European large-scale pilot of patient summary and electronic prescription).

4 FUTURE INTERNET INNOVATION: STATE OF THE ART AND DEVELOPMENTS

This chapter provides a preliminary description of the Future Internet (FI) Domain Landscape, including the Future Intenet dimensions and research domains translating the main issues and players, as well as the potential and current relationships with the Living Labs (and Smart-Cities: later on) Domain Landscape. This chapter contributes to describing and analyzing the emerging holistic domain landscape comprising Future Internet, Living Lab and Smart Cities in the context of Open Innovation.

4.1 DEFINITION AND DESCRIPTION

A definition of Future Internet is available in Wikipedia (http://en.wikipedia.org/wiki/Future Internet):

"Future Internet is a summarizing term for worldwide research activities dedicated to the further development of the original Internet. While an increased public awareness of several critical shortcomings in terms of performance, reliability, scalability, security and many other categories including societal, economical and business aspects, has led to Future Internet research efforts. Given the diversity of technologies related to the Internet, extended by lower and higher layers and applications, the related research topics are wide spread. In addition, the approaches towards a Future Internet range from small, incremental evolutionary steps to complete redesigns (clean slate) and architecture principles, where the applied technologies shall not be limited by existing standards or paradigms such as client server networking, which, for example, might evolve into co-operative peer structures." The concept of Future Internet can be analysed by distinguishing 6 main aspects (Table 4-1).

Main Aspects	Technical issues	What it does	Questions addressed
Backbone	IPV6 High speed routers ..	Service Oriented Networking Monitoring Virtualisation	Mobility Security Naming and addressing New form of route planning
Network access to services	optical fibre dev improvement of high speed internet	home networking improvement of bandwidth use	Services continuity Economic models for open networks
Spontaneous network	Ad hoc mobile network Delay tolerant network Web of Wifi P2P	Communication between vehicles , planes	
Internet of things	Active RFID technology replacing bar codes NFC techno	Chips able to detect themselves and communicate about objects	New architectures, new data bases, maintenance, data durability Huge flow of information, overload Energy consumption
Internet of contents	Congestion protocols,	Real time application for video games, TV, VoD, Triple-Play	Devices variety, access to various networks complexity of operations on content: Coding, storage, transportation …
Internet of usages and services	Cloud computing Sensors networks	New services and apps Contextual awareness	Social network Virtual communities

	API interoperability VPN	Augmented reality Telepresence	Trust Privacy Personal data storage

Table 4-1 Future Internet description

Internet of Things (IoT) is considered as a major disruptive innovation as it consists in interconnection between physical and virtual worlds with a huge amount of sensors and controllers largely distributed in vehicles, fixed devices, and close environments. One of the main questions is to find a way to link an object code with information about it, as these information will be distributed on different servers according to the stage of the production: distribution chain. There are major economic issues involved with respect to production and distribution cost reduction.

The movement towards the Future Internet is based on the belief that the current Internet has reached his limits. Tselentis (2010) states: "The current Internet has been founded on a basic architectural premise, that is: a simple network service can be used as a universal means to interconnect intelligent end systems. This simple premise has allowed the Internet to reach an impressive scale in terms of inter-connected devices. However, while the scale has not yet reached its limits, the growth of functionality and the growth of size have both slowed down. It is now a common belief that the current Internet would reach soon both its architectural capability limits and its capacity limits."

The current lack of domain landscape on Future Internet research domain appears to be an important issue for researchers. It would help to achieve a broader understanding of the Future Internet domain.

Dimensions of the Future Internet Domain

- Approaches for Internet Evolution towards Future Internet: from structured (Incremental evolution) to unstructured (Clean Slate or radical evolution from where emerge new generation networks)
- Research Types: from experimental research (testbed: functional test, users as observed subjects) to experiential and participative research (LLs: user cocreation)
- Evaluation Approach: from Reliability (Testbeds), towards Quality of Service (QoS) and Quality of Experience (QoE) for adoptability
- User Involvement: from individual users to very large or massive community of users
- Networking Types: from optic fibre to wireless communication networks
- Socio-Economic: from technological innovation to social/societal innovation.

Future Internet Research areas

Next Generation Network (NGN): a broad term to describe key architectural evolutions in telecommunication core and access networks that will be deployed over the next 5–10 years. The general idea behind NGN is that one network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets, like it is on the Internet. NGNs are commonly built around the Internet Protocol, and therefore the term "all-IP" is also sometimes used to describe the transformation toward NGN. http://en.wikipedia.org/wiki/Next_Generation_Networking

Autonomous Network (AN)

Autonomous System (Internet): a collection of connected Internet Protocol (IP) routing prefixes under the control of one or more network operators that presents a common, clearly defined routing policy to the Internet.
http://en.wikipedia.org/wiki/Autonomous_system_%28Internet%29

Autonomic Networking: follows the concept of Autonomic Computing, an initiative started by IBM in 2001. Its ultimate aim is to create self-managing networks to overcome the rapidly growing complexity of the Internet and other networks and to enable their further growth, far beyond the size of today.
http://en.wikipedia.org/wiki/Autonomic_network

Cloud Computing (CC): Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid. http://en.wikipedia.org/wiki/Cloud_computing

Cognitive Network (CN): a new type of data network that makes use of cutting edge technology from several research areas (i.e. machine learning, knowledge representation, computer network, network management) to solve some problems current networks are faced with. Cognitive network is different from cognitive radio as it covers all the layers of the OSI model (not only layers 1 and 2 as with cognitive radio). http://en.wikipedia.org/wiki/Cognitive_networks

Cross-Layer Optimisation: an escape from the pure waterfall-like concept of the OSI communications model with virtually strict boundaries between layers. The cross layer approach transports feedback dynamically via the layer boundaries to enable the compensation for e.g. overload, latency or other mismatch of requirements and resources by any control input to another layer but that layer directly affected by the detected deficiency. Especially in information routing with concurrent demand for limited capacity of channels there may be a need for a concept of intervention to balance between e.g. the needs of intelligible speech transmission and of sufficiently dynamic control commands. Any fixed allocation of resources will lead to a mismatch under special conditions of operations. Any highly dynamic change of resource allocation might affect the intelligibility of voice or the steadiness of videos. However, as with other optimizing strategies, the algorithm consumes time as well. http://en.wikipedia.org/wiki/Cross-layer_optimization

Network Virtualization: the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization involves platform virtualization, often combined with resource virtualization. Network virtualization is categorized as either external, combining many networks, or parts of networks, into a virtual unit, or internal, providing network-like functionality to the software containers on a single system. Whether virtualization is internal or external depends on the implementation provided by vendors that support the technology. http://en.wikipedia.org/wiki/Network_virtualization

Virtual Private Network (VPN): a network that uses a public telecommunication infrastructure and their technology such as the Internet, to provide remote offices or individual users with secure access to their organization's network. It aims to avoid an expensive system of owned or leased lines that can be used by only one organization. The goal of a VPN is to provide the organization with the same secure capabilities but at a much lower cost.
http://en.wikipedia.org/wiki/Virtual_private_network

Network Convergence: a broad term used to describe emerging technologies, and network architecture designs used to migrate voice and data networks into a single network. Specifically, Network Convergence describes the transition from separate circuit-switched voice network and packet-switched data networks, to a single packet-switched network supporting both voice and data protocols
http://en.wikipedia.org/wiki/Network_convergence

Quality of Services (QoS): In the field of computer networking and other packet-switched telecommunication networks, the traffic engineering term quality of service (QoS) refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. For example, a required bit rate, delay, jitter, packet dropping probability and/or bit error rate may be guaranteed. http://en.wikipedia.org/wiki/Quality_of_Service

Quality of Experience (QoE): some times also known as "Quality of User Experience," is a subjective measure of a customer's experiences with a vendor. It looks at a vendor's or purveyor's offering from the standpoint of the customer or end user, and asks, "What mix of goods, services, and support, do you think will provide you with the perception that the total product is providing you with the experience you desired and/or expected?" It then asks, "Is this what the vendor/purveyor has actually provided?" If not, "What changes need to be made to enhance your total experience?" http://en.wikipedia.org/wiki/Quality_of_Experience

Internet of Things (IoT): In computing, the Internet of Things (also known as the Internet of Objects) refers to the networked interconnection of everyday objects. It is generally imagined as a self-configuring wireless network of sensors whose purpose would be to interconnect all things. The concept is attributed to the original Auto-ID Centre, founded in 1999 and based at the time in MIT. It includes concepts such as RFID and NFC. http://en.wikipedia.org/wiki/Internet_of_Things

Internet of Services (IoS) or **Semantic Web Services**: like conventional web services, are the server end of a client–server system for machine-to-machine interaction via the World Wide Web. Semantic services are a component of the semantic web because they use markup which makes data machine-readable in a detailed and sophisticated way (as compared with human-readable HTML which is usually not easily "understood" by computer programs). http://en.wikipedia.org/wiki/Semantic_Web_Services

Wireless Internet (Spontaneous Network?): the suite of wireless protocols after Wireless Application Protocol 2.0 (WAP). It includes XHTML Basic, Nokia's XHTML Mobile Profile, and future developments of WAP by the Open Mobile Alliance. Wireless Internet Protocols are able to deliver XHTML pages to appropriate wireless devices without the need for HTTP to WAP proxies. Using Wireless Internet Protocols, web pages can be rendered differently in web browsers and on handhelds without the need for two different versions of the same page. http://en.wikipedia.org/wiki/Wireless_Internet

IP Multimedia Subsystem (IMS): an architectural framework for delivering Internet Protocol (IP) multimedia services. It was originally designed by the wireless standards body 3rd Generation Partnership Project (3GPP), as a part of the vision for evolving mobile networks beyond GSM. Its original formulation (3GPP R5) represented an approach to delivering "Internet services" over GPRS. This vision was later updated by 3GPP, 3GPP2 and TISPAN by requiring support of networks other than GPRS, such as Wireless LAN, CDMA2000 and fixed line. http://en.wikipedia.org/wiki/IP_Multimedia_Subsystem

Networked Media: rely on the technological process known as Convergence, thanks to which all kinds of media including text, image, 3D graphics, audio and video produced can be distributed, shared, managed and consumed through various networks, like the Internet, be it via Fiber, WiFi, WiMAX, GPRS, 3G and so on, in a convergent manner. Networked Media also encapsulates the concept of a decentralized medium of mass communication, in which the audience can actively contribute to the production of the media. As the Internet has revolutionised the access to multimedia content and enabled collaborative user-generated content (UGC), requirements in this field have huge impact for the Future Internet.

At the same time advances in audiovisual technologies such as Digital Cinema and 3D processing increase the level of immersion and the quality of the experience (QoE), but also give rise to innovative applications, notably in gaming technologies and in virtual worlds. In essence, Networked Media are decentralized media of mass communication, whose value chain features a network capacity, wich can allow co-operative and collaborative practices enabling users to contribute to the production of the new media.

3D Media Internet: a basis of tomorrows networked and collaborative platforms in the residential and professional domains.

Semantic Service oriented Architecture (SSoA): a computer architecture that allows for scalable and controlled Enterprise Application Integration solutions.[1] SSOA describes a sophisticated approach to enterprise-scale IT infrastructure. It leverages rich, machine-interpretable descriptions of data, services, and processes to enable software agents to autonomously interact to perform critical mission functions. SSOA is technically founded on three notions: The principles of Service-oriented architecture (SOA); Standards Based Design (SBD); and Semantics-based computing. SSOA combines and implements these computer science concepts into a robust, extensible architecture capable of enabling complex, powerful functions. See: http://en.wikipedia.org/wiki/Semantic_service_oriented_architecture

Wireless Sensor Network (WSN): consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. Wireless sensor networks are used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control. See: http://en.wikipedia.org/wiki/Wireless_sensor_network

Fig. 4-1 presents the domain landscape of Future Internet innovation based on several dimensions.

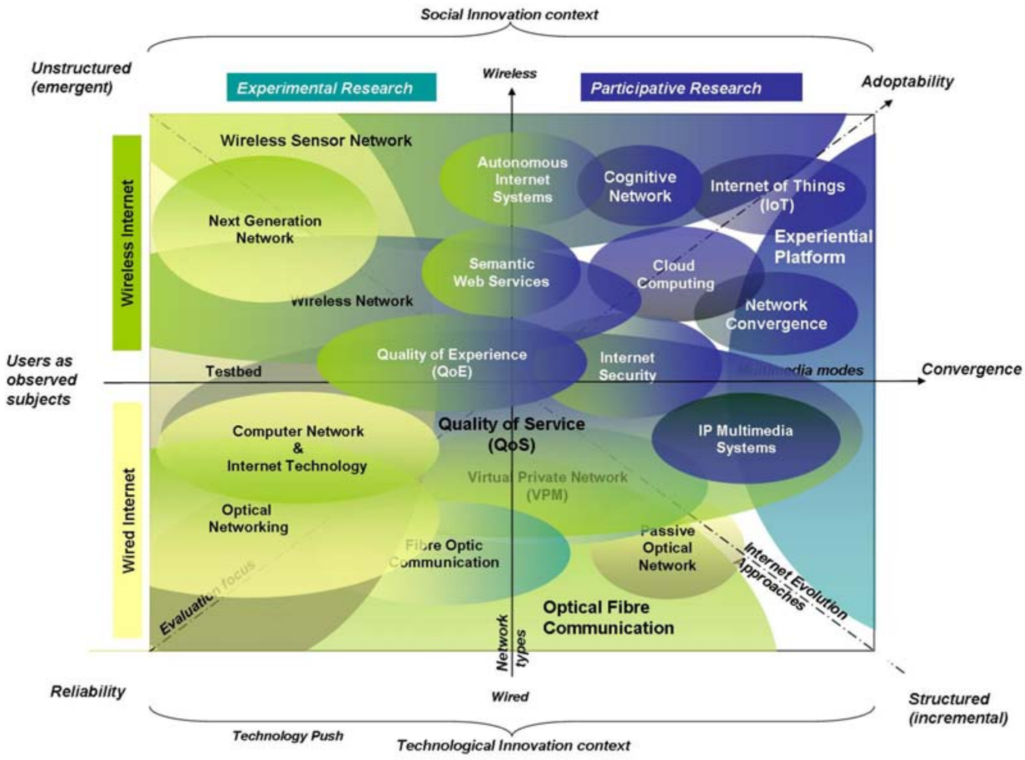


Fig. 4-1: Future Internet Domain Landscape (Pallot, Trousse & Senach , 2010)

4.2 STATE OF PLAY

We refer to available documents at www.future-internet.eu and to the FIA 2009 and FIA 2010 books. From the point of view of this report it is important to mention the current portfolio of FIRE projects, including projects related to FIRE facilities and projects related to experimentally driven research.

The Future Internet represents the evolving need for infrastructures at several levels: innovation infrastructure (networks of collaboration, experimental facilities, research and test centres etc), broadband Internet infrastructure (networks, services). Fuiture Internet is the “provider” of future Internet infrastructure and applications. Naturally, Future Internet will be the key driver of technological supports for services and products to be tested in living labs (user driven open innovation) approaches.

Fig. 4-2: EC-funded projects in the Future Internet area

The Future Internet community, at the European level, includes different distinct groups of organisations to be federated: (1) Institutions concerned with Future Internet (2) Projects, (3) Research labs, centres and experts performing research on the subject.

A federating approach needs to be developed around the following themes:

- The “Network of the Future” with a focus on solutions to cope with the issues of capacity, mobility, scalability and flexibility of the ICT infrastructure;
- The "Internet of Services" with a focus on issues such as virtualisation, dynamically composed service overlay over a modified network structure and service joint execution environments;
- The "Internet of Things” with a focus on networked object management and associated service and data discovery architectures, with integration in generic business environments.
- The "Security of ICT infrastructures and services" with a focus on secure, resilient and trusted networks and service architectures and composite end-to-end services, as well as identity management and business and personal data protection and privacy;
- The "3D Media Internet" with a focus on the architectural and related technological implications of 3D virtual environments over networked platforms.
- The "Experimental Facilities" with a focus on experimentally-driven research projects, which cut across several layers from connectivity via service architectures to applications, thereby addressing the Future Internet from a broad system perspective.

Future Internet Assembly

The Future Internet Assembly published its second book which tries to capture the emerging trends in Future Internet research, as they are presented through European funded research activities. The book contains 25 selected papers presenting a variety of European research results aimed at further developing the current Internet. It offers, above all, a vision of the future rather than an account of deployed solutions. It presents representative research results in seven interrelated area of research for Future Internet (Fig. 4-3): 1. Socio-economics; 2. Trust and Identity; 3. Experimental Research; 4. Management and Service-aware networking Architectures; 5. Service Offers; 6. Content Networks; 7. Real Word Internet.

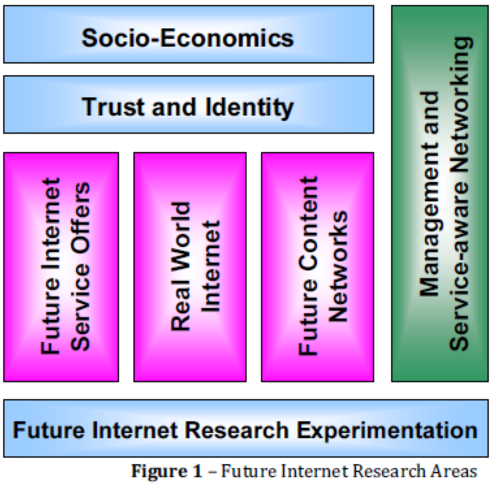


Fig. 4-3: Future Internet Research areas (FIA)

Eiffel Thinktank

Eiffel is a support action Support action of FP7 http://www.fp7-eiffel.eu/. The think-tank has identitied as immediate problems:

- Resilience, failure tracking & management
- Availability & robustness to attack
- Information security scalability
- Resource accountability:
- Network-application coordination:
- Scaling for more extreme dynamics:

The big new ideas proposed are: Interconnecting the information & physical worlds; Natural social interaction; Governance models; Cater to new communication paradigms.

EIT ICT Labs

EIT ICT Labs (www.eitictlabs.eu, Fig. 4-4) will develop and deliver:

- Excellence and entrepreneurship in education
- Future Internet infrastructures
- Novel ICT services – for individual, business and society
- User-involved solutions for research and development
- European open innovation ecosystem for ICT and its applications

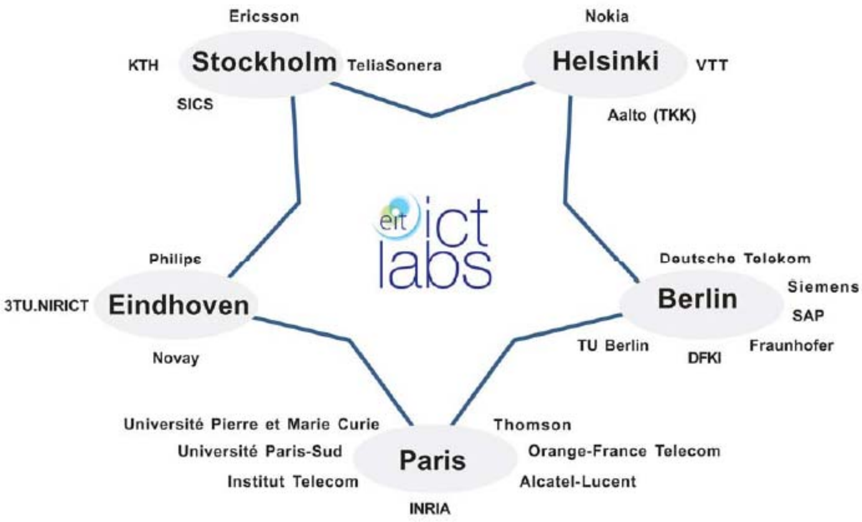


Fig. 4-4: EIT ICT Labs partner network

EIT ICT Labs aims to be a unique European arena for turning ideas into economic, social, and cultural benefits throughout the entire innovation web. The vision and mission of EIT ICT Labs is to turn Europe into the global leader in ICT innovation. EIT ICT Labs aims at the radical transformation of Europe towards a knowledge-based society turning ICT innovation into quality of life. EIT ICT Labs builds European trust based on mobility of people across countries, disciplines and organisations generate future world-class business building joint European innovation clusters.

- Improve quality of life through service based applications for citizens of Europe and beyond.
- Transform higher education to promote creativity and entrepreneurial spirit.
- Provide international top talent (experimental) ICT Labs for researchers, innovators and entrepreneurs.
- Establish five world class innovation centres in Berlin, Eindhoven, Helsinki, Paris and Stockholm.

Thematic areas:

- SmartSpaces - including service-centred home
- Smart Energy Systems - smart energy management, Green ICT
- Health & well-being - including ambient assisted living, digital medicine
- Intelligent Transportation Systems - novel forms of safer & sustainable traffic and transportation systems
- Future Media and Content Delivery - entertainment, education, accessing media
- Digital Cities - towards intelligent and sustainable digital cities

NSF GENI (Global Environment for Network Innovation)

Evolving technological and social networks, intertwined and worldwide in scope, are rapidly transforming societies and economies. The Global Environment for Network Innovations (GENI), a project sponsored by the National Science Foundation, is open and broadly inclusive, providing collaborative and exploratory environments for academia, industry and the public to catalyze groundbreaking discoveries and innovation in these emerging global networks. GENI is a virtual laboratory at the frontiers of network science and engineering for exploring future internets at scale. GENI creates major opportunities to understand, innovate and transform global networks and their interactions with society. http://www.geni.net/

GENI supports at-scale experimentation on shared, heterogeneous, highly instrumented infrastructure. It also enables deep programmability throughout the network, promoting innovations in network science, security, technologies, services and applications. Finally, it provides collaborative and exploratory environments for academia, industry and the public to catalyze groundbreaking discoveries and innovation.

The GENI community comprises different communities, such as:

- **PlanetLab**: a global research network that supports the development of new network services. Since the beginning of 2003, more than 1,000 researchers at top academic institutions and industrial research labs have used PlanetLab to develop new technologies for distributed storage, network mapping, peer-to-peer systems, distributed hash tables, and query processing. PlanetLab currently consists of 1120 nodes at 510 sites. PlanetLab is an open platform for developing, deploying, and accessing planetary-scale services. See: http://www.planet-lab.org/
- **Internet2**: the foremost U.S. advanced networking consortium. Led by the research and education community since 1996, Internet2 promotes the missions of its members by providing both leading-edge network capabilities and unique partnership opportunities that together facilitate the development, deployment and use of revolutionary Internet technologies. Internet2 brings the U.S. research and academic community together with technology leaders from industry, government and the international community to undertake collaborative efforts that have a fundamental impact on tomorrow's Internet. See: http://www.internet2.edu/.
- **National Lambda Rail**: a major initiative of U.S. research universities and private sector technology companies to provide a national scale infrastructure for research and experimentation in networking technologies and applications. See: http://www.nlr.net

Users Involvement in GENI

An important feature of GENI is to permit experiments to have access to end-user traffic and behaviors. For examples, end-users may access an experimental service, use experimental access technologies, or allow experimental code to run on their computer or handset. GENI will provide tools to allow users to learn about an experiment's risks and to make an explicit choice ("opt-in") to participate.

The GENI Gush team is designing and implementing a powerful and intuitive experiment control and management tool for GENI. Gush, which stands for the "GENI User Shell", permits users to add resources to a GENI slice; load software on to these resources; and start, stop and monitor experiments. Gush provides three user interfaces: a graphical user interface, command line interface, and a programmatic interface. It is being integrated with several of GENI's prototype control frameworks.

The objective of the Million-Node GENI project at the University of Washington is to enable millions of owners of end-user systems such as personal computers and mobile computing devices to make their systems available to GENI researchers for experimentation.

The 8th GENI Engineering Conference (GEC8) showcased a remarkable 34 demonstrations of the emerging GENI meso-scale prototype which now spans over a dozen US campuses. Nationwide, multi-campus integration is coming together extremely quickly, a testament to the very rapid and professional work of the campus IT staffs. A key feature demonstrated was the GENI Aggregate Manager API v1.0 providing direct, GENI-wide interoperability between PlanetLab, ProtoGENI, and OpenFlow. Other control frameworks become interoperable soon.

Over 260 participants from academia, industry, and government met from July 20th – 22nd in La Jolla, CA, hosted by Calit2, for the tri-annual meeting GENI Project Director Chip Elliott refers to as the "gathering of the GENI tribes." Plenary talks highlighted GENI's international collaborators from renowned research teams in Japan, Korea, and Germany, together with US researchers from Florida International University and the Starlight advanced optical network who provide strong international research linkages to a range of nations.

FIRE projects related to Experimental facilities

Experimental facilities in FIRE aim to test and validate new paradigms related to future Internet at large-scale and real-life conditions. FIRE promotes the set-up of large-scale experimental facilities, beyond individual project testbeds. These experimental facilities support research under real-life conditions, to explore interoperability, scalability and other issues. For this purpose, FIRE projects on experimental facilities develop interconnected testbeds. Projects so far include: ONELAB2, PII, VITAL++, WISEBED (first wave), and BONFIRE, CREW, OFELIA, SmartSantander, TEFIS (second wave). See Table 4-2.

In many ways the **Panlab project paved the way.** Pan-European Laboratory for Next Generation Technologies, networks and services. This is an FP6 support action project (2006 – 2008) to identify requirements of ICT industry for end-to-end testing and address these requirements by providing federated on-demand testing facilities via a Pan-European laboratory organization. The concept is based on federation of distributed interconnected test laboratories and testbeds for interoperability testing. Stakeholders: ICT industry, researchers. Short descriptions of 1st and 2nd wave projects in experimental facilities are as follows:

- **Federica:** Federated E-infrastructure dedicated to Researchers Innovating in Computer Architectures; 2008-2010; created scalable Europe-wide clean slate infrastructure to support experiments on Future Internet.
- **PII:** continues the PanLab project addressing the need for large-scale testing facilities.
- **OneLab2:** uses the PlanetLab Europe testbed (network of open computers distributed around the world) for testing of technologies such as content distribution, routing overlays, peer-to-peer social networks and geolocation services.
- **Vital++**: Pan-European testbed comprised of existing geographically distributed test sites integrated by IMS technology. This can be sued to test distribution of content to a customer base using P2P, and adapt existing telecommunications infrastructure to accelerate P2P operations.
- **WISEBED**: virtual network of sensor networks located at different locations throughout Europe.

- **BONFIRE:** building a multi-cloud facility to support applications, services and systems research targeting the Internet of Services community.
- **SmartSantander:** Future Internet research project in FP7-ICT, focused on Internet services in the city. Experimenting environment based on 20.000 sensors based on real-life IoT deployment in urban setting.
- **TEFIS:** offers single point of access to customized services allowing exploitation of different testing and experimental facilities for communities of software and business developers.
- **CREW:** established open federated testbed to facilitate research on advanced spectrum sensing, cognitive radio and cognitive networking strategies.
- **OFELIA:** this project creates an experimental facility allowing researchers to experiment on a test network but also to control the network through secure and standardized interfaces.

	FIRE facilities	Experimentally driven research
1st wave	ONELAB2 PII (federating testbeds) VITAL++ WISEBED (infrastructure of interconnected testbeds for large-scale wireless sensor networks)	ECODE N4C NANODATACENTERS OPNEX PERIMETER RESUMENET SMART-NET SELF-NET
2nd wave	BONFIRE (multi-site cloud facility for Internet of Services) CREW (open federated test platform) OFELIA SMART SANTANDER TEFIS	CONECT CONVERGE EULER HOBNET LAWA NOVI SCAMPI SPITFIRE

Table 4-2: FIRE projects overview

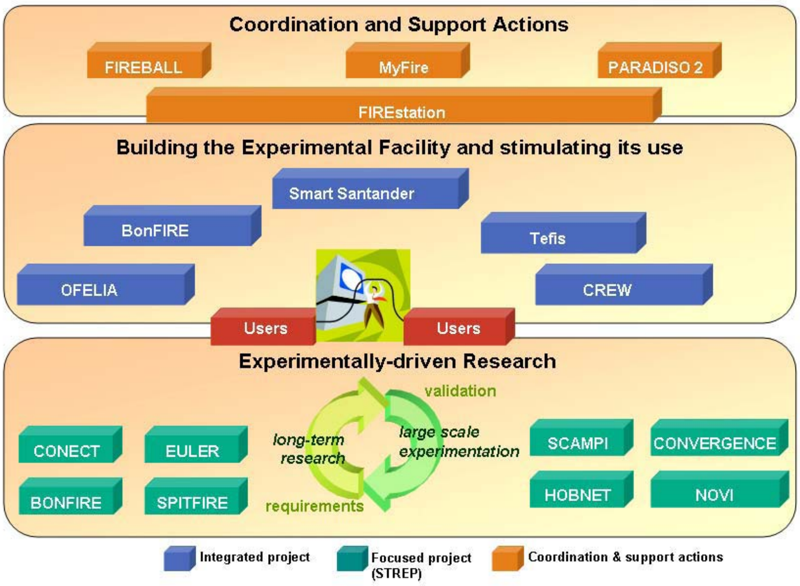


Fig. 4-5: Current FIRE projects in FP7

The role of users in FIRE

The role of users is different in FIRE facilities projects compared to living labs (Table 4-3).

- FIRE facilities projects involve users to assess the impacts of technological changes to the Internet in socio-economic terms. Living labs engage the users in the innovation process itself.
- FIRE facilities use the approach of controlled experimentation; Living labs engage the users within the actual innovation process.

	FIRE	Living Labs
Approach	Controlled experiments Observing large-scale use Federated testbeds	User co-creation by living labs methodologies Open innovation
Testing of what	Technologies, services, architectures, platforms, system requirements; impacts	User ideas, applications and solutions
Scale of testing	Large-scale mainly	From small to large scale
Stakeholders	Researchers, ICT industry	End-users, enterprises, SMEs
Objective	Facilities to support research Assess impacts of tested solutions	Support process of user driven innovation

Table 4-3: User role in FIRE and Living Labs

The Commission has clearly expressed its support for stronger user orientation in the Future Internet facilities projects. Not only users in terms of academic and industry researchers who will use these facilities for their research projects, but also end-users. Emphasis is on involving communities of end-users at early stage of development to assess impacts of technological changes.

The FIREWORKS project (now continuing in FIRESTATION) has carried out a portfolio analysis of FIRE projects. In relation to the functioning of the testbed facilities and user involvement conclusions are as follows:

- Integrated Projects have different notions of users, of use cases (related to federation) and of the range of collaborations that can be expected to augment the value of the technologies they bring to FIRE.
- FIRE differs to GENI in that FIRE emphasizes the value as seen by an end-user with its applications and services while GENI focuses more on basic infrastructure technologies.
- FIREWORKS has defined a set of issues that must be dealt with by a testbed or federation of testbeds to support real external users, e.g. user facing clearinghouse, terms and conditions, security and privacy, define, simulate and control experiments etc. These issues seem so far not to be covered systematically in the FIRE projects.
- Methods for end user involvement and end user experiments are not exploited that much. In PII this is discussed and taken up in some STREPs of Call 5.
- Cost and effort to maintain a user community is very high. Including external users is still low-level. Exception seems to be PlanetLab Europe (OneLab2). Still, end-users seem to be experts researchers only (it is mentioned astronomy as an example of users involvement). . Generally spoken: user support is a new and untested concept.
- The report recommends that the FIRESTATION project takes the lead in identifying appropriate levels of user support and ensuring that best practices are shared. Vision of end-to-end support for FIRE users needs to be integrated into upcoming Calls 7 and 8.

4.3 LINKAGES WITH OTHER COMMUNITIES

Altogether, Future Internet, Living Labs and Smart Cities form an ecosystem comprising ICT companies, research scientists and City policy makers. In this ecosystem, while Future Internet represents the technology push, Smart Cities represent the application pull and Living Labs form the exploratory and participative playground in between Future Internet and Smart Cities. In contrast with testbed[1], Living lab[2] constitutes a 4P (Pubic-Private-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 and SMEs as well as research scientists from different disciplines.

[1] http://en.wikipedia.org/wiki/Testbed a platform for experimentation of large development projects. Testbeds allow for rigorous, transparent, and replicable testing of scientific theories, computational tools, and new technologies.

[2] http://en.wikipedia.org/wiki/Living_lab is a user-centred, open-innovation ecosystem, often operating in a territorial context (e.g. city, agglomeration, region), integrating concurrent research and innovation processes within a public-private-people partnership.

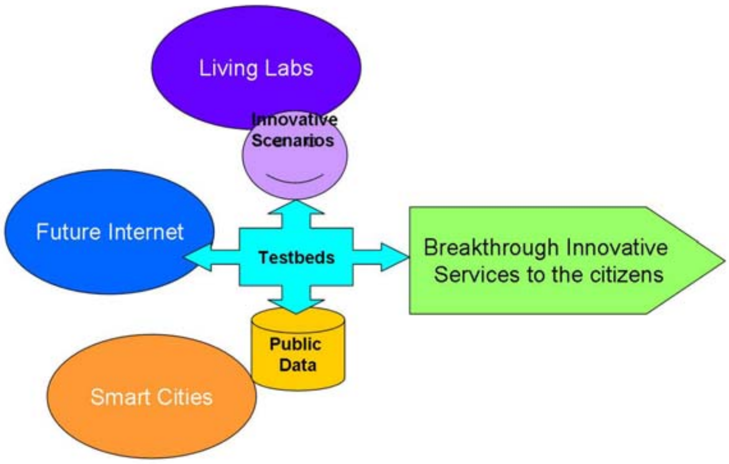


Figure 4-6: FI, LL and Smart Cities Ecosystem (Pallot, Trousse, & Senach, 2010)

4.4 EXPLOITING THE LINKAGES

There are already initial examples of projects showing the triangulation between Future Internet, Living Labs and Smart Cities such as APOLLON project with its pilot on eParticipation that involves Issy-les-Moulineaux, Manchester and Brussels. Eventually, a Future Internet testbed could be used as a technology platform 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 public data.

5 LIVING LABS FOR OPEN INNOVATION: STATE OF THE ART AND DEVELOPMENTS

5.1 DEFINITION AND DESCRIPTION

The Living labs phenomenon, which is relatively new in Europe, originated from the work of William Mitchell at MIT. He argued that a living lab represents a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real-life contexts. Integrating users in the development context would ensure a more reliable market evaluation, as well as reduce technological and business risks. The idea was also that SMEs would benefit from living labs because they would be able to share resources without commercial risk financing. Larger companies would benefit from a wider base of ideas.

In Europe, several researchers explored different aspects and contexts of living labs innovation. To mention a few: Ballon et al. (2005), Eriksson *et al*., 2006; Bergvall-Kåreborn & Ståhlbröst, 2009; Svensson & Ihlström Eriksson, 2009a; Schaffers et al. 2010; Santoro & Conte 2009, Pallot et al. 2010. Electronic journal www.ejov.org publishes about living labs innovation.

Similar as with the open innovation paradigm (Chesbrough 2003, 2006), Living Labs draws on the notion of external ideas as a resource in innovation. Living labs can be considered as a specific form of open innovation. Such an approach primarily aims at supporting innovation processes that lead to usable products and services.

Ballon et al. (2005) have developed a useful categorization of six platforms for testing and experimentation, classified in two dimensions: focus (testing or design) and maturity of technology (Fig. 5-1). The six types of platforms include prototyping, field trial, testbeds, societal pilots, market pilots and living labs. This overview is useful as it not only positions living labs innovation, but also shows the potential interrelations between Future Internet testbeds, living labs, and social and market pilots to be found in city environments.

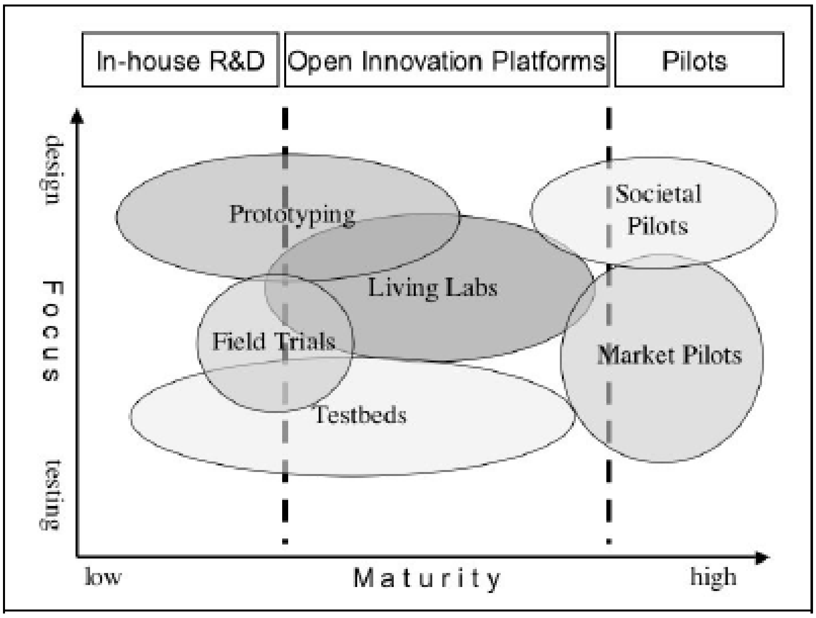


Fig. 5-1: Testing and Experimentation Platforms classification, Ballon et al. 2005

Focusing on living labs user engagement methodologies, a differentiated domain description was proposed by Pallot et al. (2010). See Fig. 5-2.

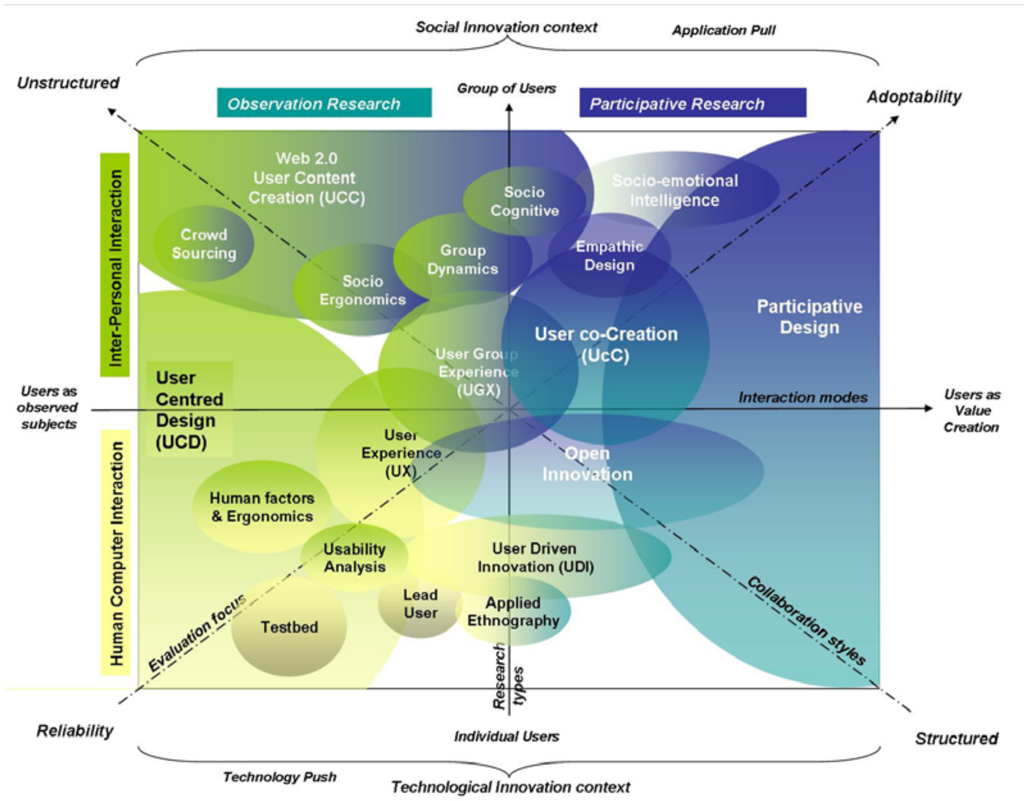


Fig. 5-2 Living labs domain landscape (Pallot et al. 2010)

Whereas this approach focuses primarily on user engagement, an approach to living labs innovation based on organizational, architectural and application development frameworks within an action research setting was developed and implemented in several pilots in the C@R project (Schaffers, Guzman, Merz, Navarro (Eds.) 2010). They distinguish between strategic and operational level methodologies. Strategic level methodologies are to initiate and establish an innovation environment including the business model, and approach to phasing living labs development. The key point here is living labs as innovation projects organisation (Fig. 5-3). Operational level methodologies aim to run living lab innovation projects and organize experimentation and evaluation cycles. Among the methodologies at that level, also showing a linkage to existing methods of software engineering and architecture development, were: cyclic development, action research (as problem oriented and collaborative approach), multi-disciplinary development groups, agile development, and methods for user community engagement.

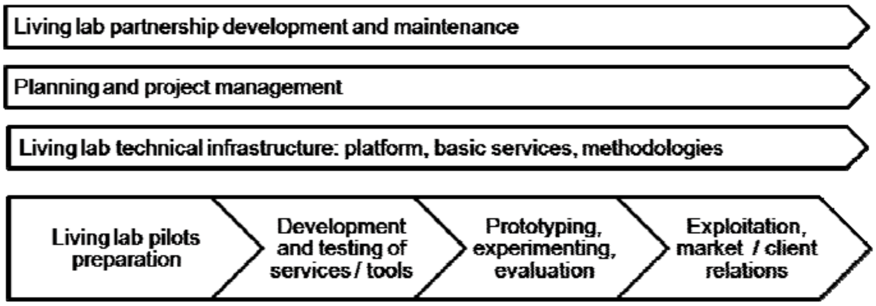


Fig. 5-3 Living lab as innovation projects organisation (Schaffers et al. 2010)

In a Living Lab approach e.g. researchers, firms, users, public partners and stakeholders of emerging technology collaborate in innovation processes in real-world settings. The phenomenon of Living Labs can be seen as a methodology, an organization, a system, an arena, environment and/or a systemic innovation approach. Based on our experience in the area we argue that a Living Lab is both an environment and a methodology or approach.

Fig. 5-4 illustrates the key components of Living Labs. The *ICT & Infrastructure* component outlines the role that new and existing ICT technology can play to facilitate new ways of cooperating and co-creating new innovations among stakeholders. *Management* represents the ownership, organization, and policy aspects of a Living Lab, a Living Lab can be managed by e.g. consultants, companies or researchers.

The Living Lab *Partners & Users* bring their own specific wealth of knowledge and expertise to the collective, helping to achieve boundary spanning knowledge transfer. *Research* symbolizes the collective learning and reflection that take place in the Living Lab, and should result in contributions to both theory and practice. Technological research partners can also provide direct access to research which can benefit the outcome of a technological innovation. Finally, *Approach* stand for methods and techniques that emerge as best practice within the Living Labs environment.

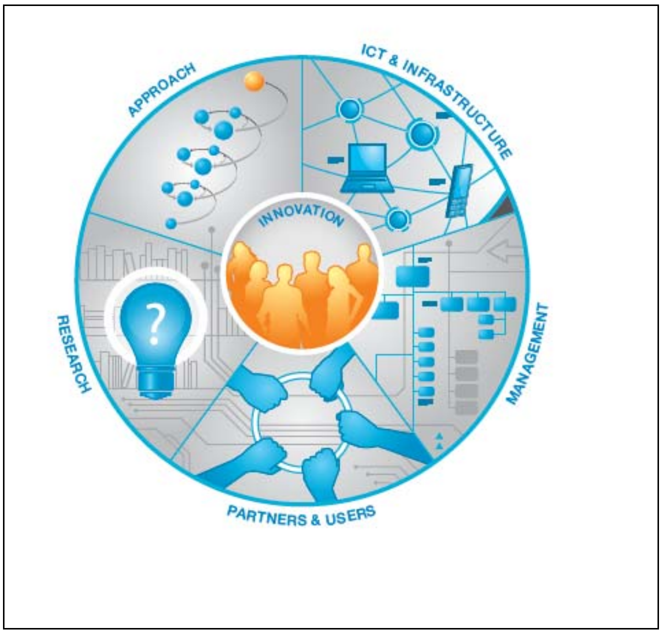


Fig. 5-4: Living Lab key components

Bergvall-Kåreborn *et al.* 2009 propose five key principles for Living Labs: Openness, Influence, Realism, Value and Sustainability.

Openness is crucial for the innovation process in a Living Lab, where it is essential to gather a multitude of perspectives that might lead to faster and more successful development, new ideas and unexpected business openings in markets. However, to be able to co-operate and share in a multi-stakeholder milieu, different levels of openness between the stakeholders seems to be a requirement. To stimulate creativity and create new ideas that can be turned into applications and bring value through use, Eriksson *et al*. (2005) suggest open collaboration between people of different backgrounds, with different perspectives that have different knowledge and experiences. More people, including consumers, need to be involved in the innovation process.

A key aspect of the **influence** principle is to view "users" as active and competent partners and domain experts. As such their involvement and influence in innovation and development processes shaping society is essential. Equally important is to base these innovations on the needs and desires of potential users, and to realize that these users often represent a heterogeneous group. This means utilizing the creative power of Living Lab partners, whilst facilitating their right to influence these innovations. By stressing the decision making power of potential users and domain experts the principle differs from related concepts such as participation, involvement, and engagement which instead focus on the activities carried out by users and users' psychological state (Barki & Hartwick, 1989; Baroudi *et al*., 1986).

In order to reduce the diversity and ambiguity related to the principle of influence, and to increase its positive impact in practical studies, it is prudent to define and explain the concept as clearly as possible.

One of the cornerstones for the Living Lab approach is that innovation activities should be carried out in a **realistic**, natural, real life setting. Orchestrating realistic use situation and user behaviour is seen as one way to generate results that are valid for real markets in Living Lab operations (CoreLabs 2007). However, the aim to create and facilitate realism is an endeavour that needs to be grappled with on different levels and in correlation to different elements such as contexts, users, use situations, technologies, and partners. The principle does not separate between the physical and the online world. Instead we argue that activities carried out in both worlds are as real and realistic to its actors.

Living Lab has the opportunity to create **value** based on all aspects of the value term: economical value, business value and consumer/user value and has to be viewed from different stakeholder perspectives.

Stakeholders	**Source of value**
Government	• Participative activities via citizen involvement • Regional and national development • Increased return of investments on innovation research
Companies	• Faster development cycles • More innovative ideas, both amount and heights • Developing right products • Reduced level of risk (higher level of adoptability) • Easier implementation • Access to a broader market • Better uptake of innovations • "Neutral" playing arena • New collaborations
Users	• Being able to influence technology development, hence getting what they need and want • Reduced level of risk (higher level of adoptability) • Getting access to test the latest technology before others • Opportunity to be involved in development of the society
Researchers	• Collaboration with users and companies • Real life comparative cases of new ways to perform, for example • Explore user involvement activities • Experiential development processes • Facilitate cross border networking • Experiment and evaluate technology artefacts • Facilitate technology transfer activities

Table 5-1: Sources of value in a living lab

Sustainability refers both to the viability of a Living Lab and to its responsibility to the wider community in which it operates. Focusing on the viability of the Living Lab highlights aspects such as continuous learning and development over time. Here, the research component of each Lab plays a vital role in transforming the everyday knowledge generation into models, methods and theories. Other important aspects related to the sustainability of a Living Lab is the partnership and its related networks since good cross-border collaboration, which strengthens creativity and innovation, builds on trust, and this takes time to build up. In order to succeed with new innovations, it is important to inspire usage, meet personal desires, and fit and contribute to societal and social needs.

However, in line with the general sustainability and environmental trends in society it is of equal importance that Living Labs also take responsibility of its environmental, social, and economic effects.

From the components and principles described above this is the Living Lab definition (Bergvall-Kåreborn *et al.* 2009): A Living Lab is a user-centric innovation environment built on every-day practice and research, with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-life contexts, aiming to create sustainable values.

5.2 STATE OF PLAY

European Network of Living Labs

In order to join forces, coordinate activities and share learning experiences, a European Network of Living Labs (ENOLL) has developed. This community of Living Labs is a loosely connected group that is organizing itself into a more structured network with the increasing size and influence of the ENoLL. At present the network has been through 4 expansion phases and currently has 212 members. Most of these members are in Europe, but 25 Living Labs are on other continents. Together the partners join forces as a network, to develop and offer a gradually growing set of networked services to support the "Innovation Lifecycle" for all actors in the system: end-users, SME´s, corporations, public sector and academia. It all starts by involving people in the streets and the users and user communities as contributors and co-creators of new innovations, of which the Future Internet is an important enabler and offers many possibilities as a platform for Living Lab and User Centric Innovation.

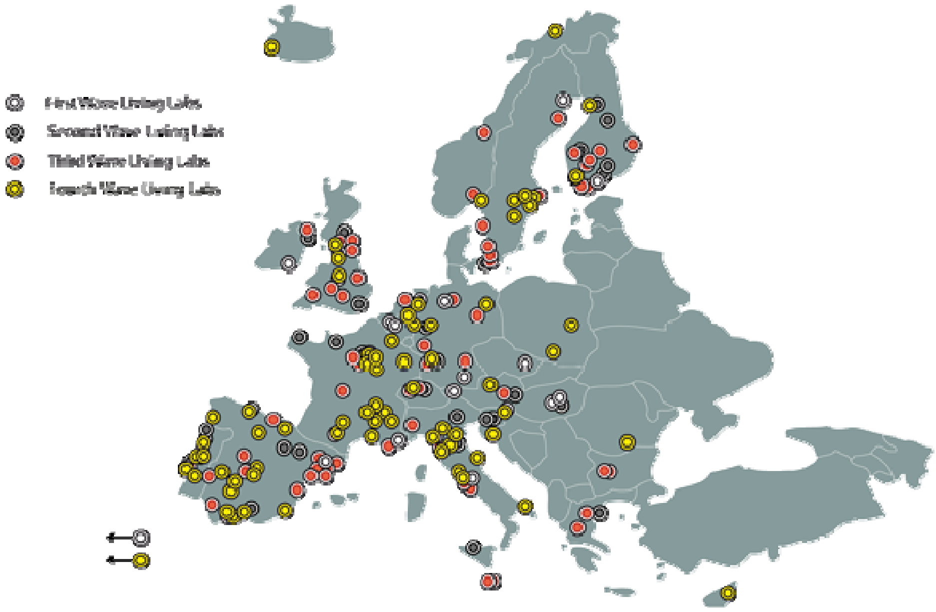


Fig. 5-5: Members of the ENoLL April 2010

Example: Botnia Living Lab

Botnia Living Lab (hosted by Centre for Distance-spanning Technology at Luleå University of Technology in Sweden) is a RDI cooperation to support human-centric innovation of advanced ICT Services for "Extending Human Capabilities". The basic idea is to engage end-users, individuals and stakeholder organisations, along a targeted value chain, in the total process from need-finding and idea-generation, through concept-development and prototype/usability testing to service piloting. The Botnia partnership includes some of the strongest international ICT/Telco organisations, numerous SMEs as well as national and regional public authorities and 7000 creative end-users from entire Sweden. Read more at: www.cdt.ltu.se and www.testplats.com (in Swedish)

Some examples of projects in Botnia Living Lab related to smart cities are:

- Smart traffic: The **iRoad** project is creating Intelligent Transport Systems (ITS) solutions for a fully integrated intelligent road to be tested in real-life settings under different climatic conditions. This intelligent road solution consists of sensors, processing capabilities and communication devices as complement to intelligent infrastructures and intelligent vehicles. The solution builds upon integrated intelligent road marking units that can gather information on road conditions and road properties. Additionally, the motion and position of vehicles travelling on the road is also of large interest, when it comes to the design of traffic management system and safety/support systems for road users.
- Smart people: The purpose with the **SATIN project** is to make it easier for end users to develop mobile services. In SATIN, a tool for visual programming is developed which greatly simplifies the process of developing services. Service components are picked and composed using "drag-and-drop" technique. Additionally, digital market places are studied, where services may be displayed and purchased. The SATIN project also look into business models regarding mobile services and open-innovation methodologies.
- Smart energy: The **SAVE Energy** project is focused on how to reduce the energy consumption in public buildings via a changed user behavior. The House of culture in Luleå is one of totally 5 pilots around Europe. The **Saber project** focuses on reducing energy consumption in house-holds. The complete solution, from the router collecting the sensor data to a personal visualition on a mobile or webb page, is developed in the project together with the users. The system is currently under test at 100 private homes. In **SITE** the aim is to develop energy consumption visualization services based on user needs and motivations in a school environment. Young pupils are engaged as co-creators of the solutions.
- Smart future Internet technologies: The **C4 program** is designed to support the special communication needs of harsh and challenging environments encountered in many settings from process and manufacturing industries, power companies to rural communities. **Basicnet**: *Broadband Access Services In Converging Networks:* The project targets the extension of the infrastructure based access network architecture to enable mobility of available and new broadband services in heterogeneous multihop wireless cum wired scenarios. **i2:** *The Intelligent Inland road:* The project is focused on evolving technology for the Intelligent car and road. New technology that can provide safer and cleaner transport systems and new business to the region. **Oricane** develops green software technology for a wide range of Internet applications. The goal is to reduce the total power consumption of the Internet and to minimize the environmental impact of Internet´s explosive growth.

Recently started "Sense Smart City" is a Swedish RDI project to make urban cities/areas "smarter". The project will generate new and better ICT solutions, which enable urban areas to gather and combine information (energy, traffic, weather, events, activities, needs and opinions) continuously as well as "on-demand". This will enable city environments to become "smarter", as more adaptive and supportive environmental, for its inhabitants and visitors - people as well as organisations.

The increased "smartness" will be recognized and measured in many ways, for example how resources (energy, public transportation, infrastructures, environments etc) are utilized and managed. The smartness will also be recognized in how quickly and efficiently new needs can be addressed, how problems/congestions are avoided and more swiftly resolved, and how information is provided more proactively and accurately with less risk for "information overload", based on increased system "awareness" and "responsiveness" towards changing local/regional needs, conditions and contexts.

Project activity plan includes four smart city pilot services/operations .Using these pilots as drivers, project will build capacity and perform scientific research in the area of smart city specific needs for communication, mobile systems and services. It also includes pilot implementation and utilization of distributed sensor systems for smart city services.

5.3 TRENDS AND DEVELOPMENTS

Looking at the five key-principles above and in the perspectives of the Future Internet Open Innovation landscape the Living Lab evolution over two decades may be summarized as follows (Table 5-2).

Key principles	From	To
Value Creation	Research and development experiments with the purpose to generate new knowledge and new artefacts (prototypes)	Also include "Innovation", where experimental processes are designed to also create new practical and substantial values and new businesses.
Influence	Users being studied as "human factors" (by researchers and industry)	Users being "human actors", taking active part and sometimes even are the drivers of activities and processes.
Openness	Low publicity experiments with/by invited partners	High publicity experiments with openness for any partner to contribute and participate.
Scale	Local experiments with limited groups of users/partner	Cross-border and cross-cultural experiments with large user groups and many partners
Sustainability	Single project/campaign missions, after which experimental environments and user/partner relations are essentially dismounted/disengaged	Continuous missions and partnerships where experimental environments and user communities sustain and mature, over time and in continuity to become valuable assets for new experiments, projects and campaigns.

Table 5-2: The Living Lab evolution

5.4 LINKAGES WITH OTHER COMMUNITIES

The Living Labs offer many diverse ways to test new and innovative services in their natural environment. The future internet community can use Living Labs for building and creating the services and applications that will enable the Future Internet to grow and justify itself.

The Living Labs form the Human centered innovation platform of choice for researching services and their production in everyday settings. The large user communities that can participate in the Living Lab projects and the diverse background of these user communities give advantages to the utility, reliability and validity of the results that are difficult to get with other forms of study. The methodologies used in Living Lab research are aimed at building and sustaining a cyclical process of enhanced interaction between the users, the researchers and the developers of the service or product under study. With this powerful interaction the Living Labs offer the tools that the future internet community needs for continuing and expanding the research.

Smart Cities can work with established Living Labs in their cities, but also enjoy the benefits that the growing network of Living Labs offer to create a wider base for testing the services and concepts that are developed within the framework of smart cities.

The common assets of the three different communities lie partly in the value that the open nature of the development and innovation strategies offers. The use of human centric development tools and the diversity of experiments that are done by Living Labs make cooperation with the Smart cities and Future internet Communities logical and without big obstacles.

5.5 EXPLOITING THE LINKAGES

Service development, validation and enhancement through user interaction is natural in Living Labs. This presents opportunities both to the Smart Cities and Future Internet Community to establish early versions of services, enabled by advanced (Future Internet based) technology platforms in real life settings and to test near to market technologies in a creative and inclusive environment. The benefits are for all involved clear and advantageous. The increased use of Living Labs in cutting edge technologies and applications offered by the Future internet and Smart Cities communities will enable the Living Lab Community to enhance its expertise in this field and give new impulses in the development of these services and technologies, and new impulses in collaboration models with smart cities and Future Internet stakeholders and facilities.

The trend towards a more pronounced role of users in Future Internet projects will contribute to building bridges with living labs activities. Equally the real life testing and validation platforms that are offered by Living Labs, combined with the cyclical and interactive nature of user driven open innovation that characterizes Living Labs will form important components of major testing and learning platforms for Future Internet Research.

6 MAPPING THE LANDSCAPE OF FUTURE INTERNET AND SMART CITIES

6.1 LANDSCAPE ELEMENTS

This chapter presents some initial views about creating a landscape map, which will be elaborated in next report versions. We will discuss bottom-up and top-down approaches. The landscape can be defined as a cloud of elements and topics characterizing the three communities composing the FIREBALL ecosystem: Future Internet, Smart Cities and Living Labs. Table 6-1 presents an overview of such elements. However, the landscape map does not consist only of such elements. It is also about relationships between elements, about complementarities and synergies. Also the elements and their interrelations are dynamically changing. A top down perspective will complement a bottom up view (elements). Table 6-2 proposes a high-level framework to identify each domain specified by aspects: assets and strengths, methodologies, actors, priorities, and value creation. The "horizontal" view may help recognizing the interrelations, synergies and complementarities for each of the aspects.

Living labs	Future Internet	Smart Cities
1. Living Lab origins 2. Living Lab initiatives in the EU 3. Living Lab initiatives - NORDFORSK 4. Living Lab initiatives globally 5. ENoLL 6. Living Lab methodologies in different sectors (health, energy, rural development) 7. Living Labs and smart city strategies 8. Living Labs and Future Internet-enabed services 9. Living Labs, local alliances and authorities 10. Living Labs and ICT infrastructure 11. Living Lab research 12. Living Lab innovation approach / perspective 13. Living Lab services provision 14. Living Lab service creation 15. Living Lab service architectures 16. Collaborative innovation eosystems 17. R&D open platforms 18. Collaborative R&D networks 19. Collective intelligence 20. Participatory foresight and futures techniques 21. Technology absorption networks 22. Knowledge spillovers 23. Collective learning 24. Technology transfer 25. University –industry cooperation 26. Collaborative New Product Development 27. Crowdsourcing 28. Co-design / participatory innovation	1. Future Internet genesis 2. FIRE research 3. Future internet technologies 4. Future internet architectures 5. Future internet applications 6. Experimental FIRE facilities and user involvement 7. Technological developments and large-scale projects 8. Future Networks 9. Software and service architectures 10. Internet of Things 11. Networked enterprises 12. Large-scale test-beds and experimentation facilities 13. Emerging constituencies and collaborationships: FIA, ETP's, large-scale project consortia, national innovation agencies, Future Internet PPP (etc) 14. FIRE and open innovation 15. FIRE and users involvement 16. Future Internet-enabled services for Smart Cities 17. FIRE, security and privacy issues 18. FIRE legal and regulatory issues 19. FIRE and Living labs experimentation 20. FIRE and Smart cities innovation 21. Web 3.0 22. Open data API 23. Open data intelligence 24. Semantic web 25. Semantic mash-ups 26. Semantic databases 27. Wireless sensors 28. Ambient intelligence 29. RFID	1. Defining and understanding Smart Cities 2. Smart / intelligent cities origins 3. Digital cities 4. Cyber cities 5. Intelligent cities 6. Smart City policy priorities in socio-economic development: health, energy, environment, education, business 7. Broadband city strategies 8. Fiber optic deployment strategies 9. Broadband technologies 10. Broadband infrastructure 11. Cable broadband networks xDSL technologies 12. Fiber optic broadband networks 13. Wireless broadband networks 14. Broadband networks mDSL 15. Broadband business modelsB 16. Broadband regulatory and financial models 17. Digital and intelligent cities concept to attract business interest 18. Future Internet pilots in Smart city environments 19. Living Labs pilots in Smart City environments 20. Smart cities and open innovation ecosystems 21. Smart marketplaces / Central Business Districts 22. Smart Health networks / applications 23. i-Universities and campus 24. Intelligent incubators and technology parks 25. Intelligent industry clusters 26. Smart traffic applications 27. Energy saving and

29. LL good practice 30. Project Apollon, 31. Project Save Energy 32. LL and the CIP programme 33. Open platforms supporting LLs	30. Cloud computing 31. Virtualisation of infrastructure 32. EU research on FIRE 33. New European initiatives, e.g. EFII/Future Internet PPP, EIT, ETP's, FP7 programme 34. Priorities within national programmes of research and innovation in Future Internet 35. FIRE and the death of the web	optimization applications and districts 28. Smart energy grid 29. Water management monitoring and alert 30. Real time air quality monitoring and alert 31. Smart safety and emergency management 32. Intelligent city strategies 33. Smart city profiles 34. Smart city good practice 35. Smart / intelligent cities in Asia, US, EU 36. Smart / intelligent cities in the US 37. Smart cities performance measurement and benchmarking

Table 6-1: Elements of the landscape map

	Future Internet	Smart Cities	Living labs
Actors, constituencies	• FIA, ETPs • National and EU research organisations • ICT sector	• Cities, urban area authorities • Partnerships	• Cities, regions, innovation agencies
Priorities	• Advanced experimental facilities for R&D • Resolving future Internet challenges: routing, scalability, mobility etc.	• Quality of life and attractiveness of cities (health and care, infrastructure, social innovation) • Innovation, work, economic development	• Cities as platforms for ICT-based innovation • Accelerate SME innovation • Foster entrepreneurship
Resources and strengths	• Technology base • Degree of organization	• Clear city development policy priorities	• User centered innovation • Potential mediating role
Methodologies	• Testbeds and experimentation facilities	• Public-private partnering • Open innovation	• User driven innovation
Value creation potential	• Uptake of technologies in network infrastructure	• Create open innovation ecosystem	• Accelaration of innovation cycles

Table 6-2: Elements of the landscape map

6.2 LANDSCAPE MAPPING BASED ON ELEMENTS

The profile of each element identified in Table 6-1 will be defined by properties such as actors, processes, technologies, applications. Property categories should be common for all topics to enable mapping of interrelationships. Mapping the landscape thus will allow visualizing the relationships among the elements that emerge from their properties / topics. We can produce multiple 2-dimensional maps by selecting the respective axis (technologies / processes; actors / applications; etc.). See for instance the mapping of the term "New York" by the mapstan machine which used as reference websites that speak about New York.

Fig. 6-1: Mapping "New York"

There are different ways to define the main elements of the Landscape:

(1) We may create of a corpus of reference to sustain the selection / definition of the main elements of the landscape. For instance, We may create an online library of about 100 documents (papers, books, reports) in each of the three major dimensions of FIREBALL (smart cities, Living Labs, future internet). The analysis of this literature may suggest which are the main subjects in each of the three FIREBALL dimensions.

(2) We may use online search, indexing and visualization tools. See for instance a document analysis of papers stored in the FIREBALL Literature and Background Documents folder at BSCW (http://www.ami-communities.eu/bscw/bscw.cgi/545087). Indexing "THE SMART CITY INFRASTRUCTURE DEVELOPMENT & MONITORING" using the online tool: **www.wordle.net** provides the following picture.

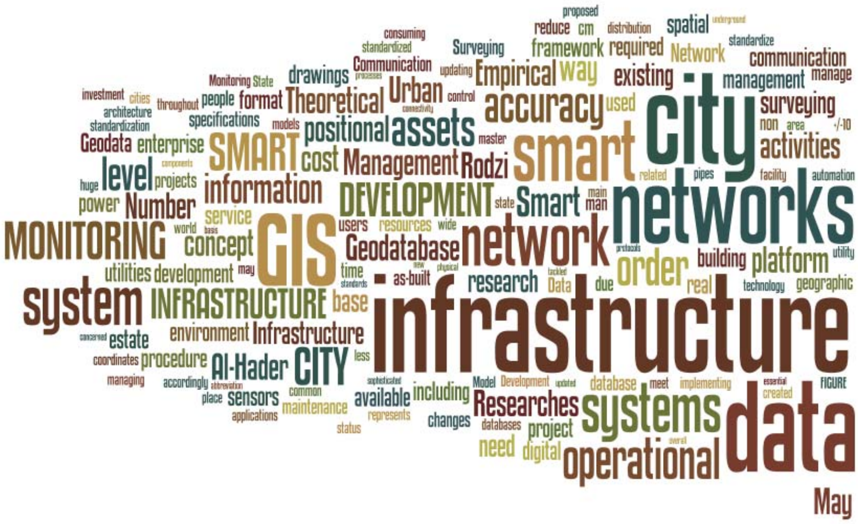


Fig. 6-2: Indexing Smart City Infrastructure Development

Another approach is website analysis. Indexing of the IBM site on Smart Cities (http://www.ibm.com/smarterplanet/us/en/sustainable_cities/ideas/) Using the online tool: **http://www.tocloud.com/**

Fig. 6-3: Website analysis of Smart Cities

The above visualizations indicate a number of elements which characterize the discussion (landscape) about smart cities and sustain our selection of the FIRE – Living Labs – Smart Cities landscape. A richer yield will be produced taking into account the other two dimensions about Living Labs and Future Internet research.

6.3 STRUCTURING THE SMART CITIES LANDSCAPE: A LAYERED VIEW

The "Landscape" covers key dimensions of the (future) innovation systems of smart cities: technologies, applications, users and uses, methodologies, actors and policies. 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: city and urban development, innovation facilities and processes, networked applications and innovations, Internet technologies and services. For each layer, "sub-maps" can be created e.g. 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.

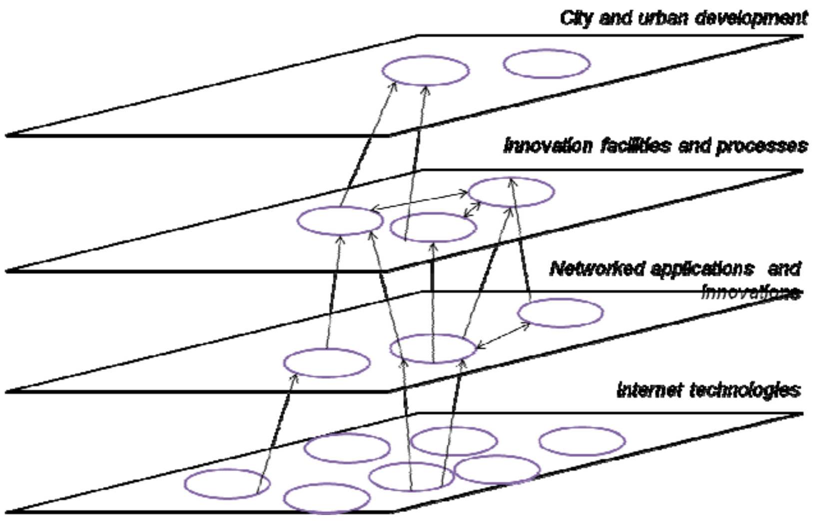


Fig. 6-3: Layered view of the landscape

6.4 SMART CITIES LANDSCAPE DYNAMICAL CHANGE

The landscape of smart cities and open innovation will change continuously, as changes are happening at every layer, e.g new technologies, and new innovation policies. Drivers of change include:

- Generic trends, e.g. technological developments, demographic change, societal changes, regional developments.
- Actor strategies and policies. Many cities have developed explicit smart city strategies for urban development and open innovation to enhance attractiveness of cities for business and citizens.
- Sector specific trends related to demands and solutions in health, energy, government, manufacturing and other.

6.5 A ROADMAP FOR GUIDANCE TO POLICIES AND STRATEGIES

The "landscape" covers the interconnected key dimensions of the (future) innovation ecosystem of smart cities: technologies, applications, users and uses, innovation environments, actors and their policies.

The landscape embodies a map of opportunities as well: both opportunities for integrated methodologies (stemming from future internet research and experimentation approaches and living labs open innovation, as well as urban innovation policies) and opportunities for smart city innovations.

Complementary to the landscape is a roadmap for realizing the ambition of smart cities as innovation ecosystems. The roadmap presents the state of the art, trends and developments, and identifies gaps and bottlenecks or challenges regarding the transformation towards smart city innovation ecosystems, fostering a process of change and transformation towards realizing the vision of smart cities' socio-economic and cultural development.

The roadmap recognzes the dynamic and uncertain aspects of change in the smart cities' landscape, and connects push and pull developments. Fig. 6-4 visualizes the main elements of the roadmap, addressing demand issues, technology developments, and innovation ecosystem changes mediating between demand and supply..

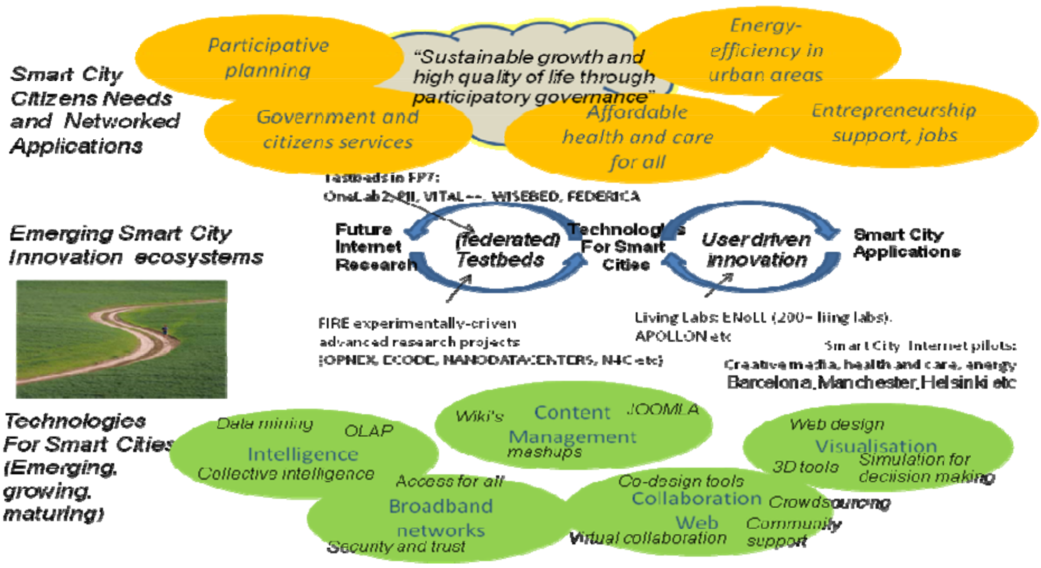


Fig. 6-4 FIREBALL roadmap concept

An initial view of the FIREBALL roadmap, which is to be elaborated in the next period through a dialogue with all stakeholders, is presented in Fig. 6-5.

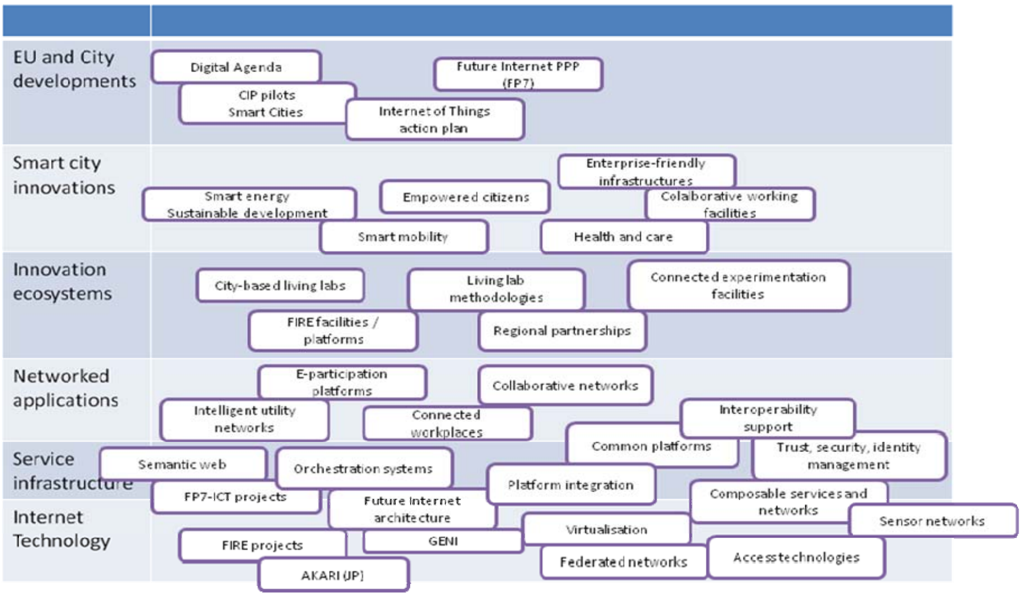


Fig. 6-5: FIREBALL initial roadmap

7 TOWARDS MODELS OF COLLABORATION

One of the priority topics within FIREBALL is to examine and explore models of collaboration among the three communities: Future Internet research and experimentation, Living labs, and Smart Cities. Such collaboration would imply collaboration within the innovation-ecosystem constituted by the interplay between the three constituencies. Some of the elements of collaboration models, including the linkages between constituencies, were mentioned in earlier chapters and here we take a more integrated view.

The facilities or resources in use by activities regarding the Future Internet, Living Labs and Smart Cities communities together constitute the technical infrastructure or resources of an urban innovation ecosystem comprising ICT companies, researchers and policy makers as well as other businesses and citizens. This ecosystem is strengthened by the determinants of the city value creation system such as infrastructure, actor networks, entrepreneurial conditions and innovative demand, as well as government policies. The collection of facilities or resources constitutes the basic infrastructure of innovation processes. A challenge is to create a strategic management approach to innovation ecosystems in which these resources are **aligned** in order to create synergies and complementarities from bottom-up. Managing innovation at the level of urban innovation ecosystems thus becomes a task of managing the **portfolio of resources** and fostering fruitful interlinkages.

Some of the key resources in the smart cities' innovation ecosystem, and the processes they facilitate, are the following (see Ballon et al. 2006; added: Innovation Community, Venture Lab).

- Testbeds. The role of testbeds is experimenting and testing of Internet technologies on dedicated platforms. System requirements dominate the validation process in testbeds (user requirements dominate living lab innovation). Main actors involved are researchers and business. Outcome of testbed processes is validated technology in the form of software and hardware components.
- Living labs. The role of living labs is to organize open innovation driven by users. Interactions involving software developers and end-users (citizens, business) proceed interactively and evolutionary.

- Field Lab. Field labs implement field trials is to test applications and solutions in practice, involving real user groups.
- Prototyping platform. This facilitates a process starting from user requirements and creating a software "model" of the final product or service. It can be seen as part of larger development process, resulting in proof of concept.
- Social pilots. An environment for introducing and validating mature solutions (products, services).
- Innovation Community. A community of citizens, domain experts, researchers, companies, stakeholders willing to meet and interact to create and shape innovative scenarios and service concepts.
- Venture Lab. Environment of business creation based on service and product concepts.

The outputs of these resources differ in several respects. Outputs of testbeds result in technologies that are adopted in the longer term. Outputs of prototyping and innovation community are used in upstream processes. Outputs of social pilots can be expected to be adopted on the short term. The "glue" linking these resources and processes is not or not always their outcome but **knowledge and information**.

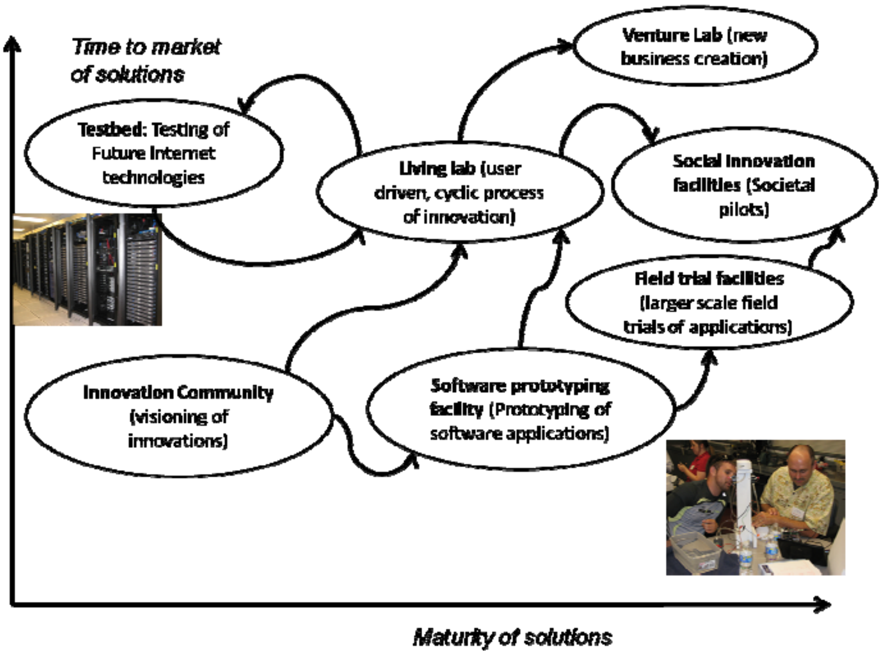


Fig.7-1: Smart City ecosystem as portfolio of assets

The role of smart city innovation ecosystem management is to manage the portfolio of "innovation assets" made up of the different facilities and resources, through fostering the knowledge and information flows created and investing or disinvesting in those resources.

8 CONCLUSIONS AND OUTLOOK FOR NEXT PHASE OF WORK

Next phase of work will elaborate the concepts and analysis introduced in this document. Particular attention will be devoted to collaboration models, and to identifying initial evidences of such collaboration. Also we aim to further elaborate the roadmap as guidance for smart city ecosystem stakeholders to create and implement new collaboration models.

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