# Integrating Living Labs with Future Internet Experimental Platforms for Co-creating Services within Smart Cities

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**Abstract**

This paper examines the potential integration of Living Labs concepts of open and user driven innovation with Future Internet experimentally driven research approaches, in order to accelerate the user-driven development of Future Internet enabled services towards Smart Cities. Two key issues are underlying this integration: strengthening user involvement in experimental Internet research, and providing access to common resources such as testbed facilities and living lab resources. To explore the opportunities for such integration, three case studies from current FP7-ICT projects are discussed: SmartSantander, TEFIS and ELLIOT. A framework is proposed facilitating the sharing of resources offered by existing Smart City platforms, testbeds and living labs facilities as a basis for partnership agreements implementing open innovation approaches for Smart Cities.

**Keywords**

Future Internet, Experimental Facilities, Living Labs, Experimentation, Internet of Things, Smart Cities

## 1 Introduction

Experimenting and evaluating Future Internet (FI) technologies, services and user scenarios is not a trivial challenge due to the complexity of issues and diversity of stakeholders. This is especially true when different research communities are involved in this process through different methodology traditions such as 'Future Internet Research and Experimentation' (FIRE), 'Living Labs', 'Internet of Things' (IoT) and 'Smart Cities'. Further to this, engaging all stakeholders including communities of users/citizens for co-creating societal important Future Internet enabled services makes it even more complex. Today, involving users in research, design and innovation processes constitutes a fast growing topic as shown by the rapid growth of the European Network of Living Labs (ENoLL, www.openlivinglabs.eu) with currently more than 200 Living Labs. However, Living Labs need technology platforms such as the ones proposed by the FIRE community, where stakeholders jointly can co-create and evaluate new scenarios such as energy management, smart mobility, environment monitoring and homecare services that contribute to turn traditional cities into Smart Cities. The challenge is therefore to identify how to properly articulate Living Labs with FIRE and IoT testbeds in order to make sure that innovative services enabled by the Future Internet will meet the expectations and desires of user communities.

This paper studies emerging insights and experiences regarding the integration of Living Labs, Future Internet and Internet of Things platforms targeting service innovation, based on FP7-ICT project cases from TEFIS, SmartSantander and ELLIOT. A key objective is to propose a framework towards the development of Smart Cities experimental environments based on such integration, with emphasis on mechanisms to ensure easy access and sharing of common research and innovation resources. Building on such mechanisms for openness and access to common resources, we envisage new patterns of collaborative innovation among stakeholders.

## 2 Background

Cities can be considered as "civic laboratories" [Institute for the Future 2010]. A city can be termed "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" [Caragliu a.o. 2009]. Whereas the current Internet and broadband infrastructure is already an indispensable component of urban innovation ecosystems nowadays, the emerging Future Internet constitutes a key infrastructural requirement for the future to fulfil the promise of the smart city concept [Komninos 2008]. Such innovation ecosystems will facilitate the co-creation of services, in environments that stimulate open innovation and early end-user involvement.

Therefore, a challenge of paramount importance is to bring together the methodological approaches as well as facilities and resources of Future Internet projects [European Commission 2010] and of Living Labs initiatives [Bergvall-Kåreborn et al. 2009] within the policy setting of Smart Cities. In the field of living labs, both the C@R Integrated Project [Schaffers, García, Navarro, Merz (eds.) 2010] and the currently running Apollon project (www.apollon-pilot.eu) provide examples of sharing diverse resources such as technologies, service components, platforms, living lab facilities and business ecosystem concepts across multiple pilots at different locations. Current FIRE projects create federated and interconnected experimental facilities for enabling experimental research. Future Internet experimental research primarily aims at investigating and validating innovative networking architectures and service paradigms. Several FIRE projects are targeting technologies and service concepts of high importance for end-user applications, such as Panlab (Web TV over mobile), TEFIS (mobile content sharing), Bonfire (on-demand applications) and SmartSantander (Internet of Things experimental facilities at urban scale). Other projects in FP7-ICT as well as in the CIP ICT-PSP also address Internet technologies, such as Internet of Things and sensor networks, and promote end-user involvement in co-creation, exploration, experimentation and evaluation (ELLIOT).

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

## 3 Methodology for Identifying and Characterising Common Assets

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

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

Table 1: Common assets for Future Internet experimentation and Living Labs

Table 1 presents the typology of assets and the services offered by the assets. Common assets include human, organisational, technological and infrastructural resources and capabilities. Providing access to and sharing common assets forms the foundation of collaborative partnerships that are underlying the transformation towards Smart Cities. The next section presents three cases that focus on identifying the common assets to facilitate such transformation.

# 4 Case Studies of FIRE, IoT and Living Labs Common Assets

## 4.1 SmartSantander: A City-wide Experimental Facility

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

The asset will be operated and maintained by the consortium during the execution of the project. After that period, several solutions are being considered. Among the choices that currently are being envisaged are the creation of a new legal entity for its exploitation, and/or the transfer of both maintenance obligations and ownership to a third party. In both cases, the use of the asset would have to be bound to legal and financial conditions. The benefits of the infrastructure addressed by the SmartSantander project are two-fold (see Table 2 for common assets):

- The deployed facility will enable a wide range of experimentations, supporting different technology aspects and catering for different user groups (researchers, service providers, and end users). Furthermore, the project collaborates with other FIRE projects to allow the federation with their respective experimental facilities.
- SmartSantander aims at optimizing the societal benefits of investing to build up such a city-scale infrastructure, so it has been designed to support real life services, useful to the citizen, at the same time it copes with its primary target of providing an ambitious experimentation platform for the research community. E.g. first cycle deployment consists of a big number of parking sensors able to provide support for experimentation of multi-hop techniques on different topologies, and will also provide the City Council means to control the proper use of the parking spaces reserved to disabled people.

| Asset type | Specification of the asset | Shareable asset |
|---|---|---|
| Network infrastructure | Heterogeneous Wireless Sensor Network, with specific experimentation capabilities allowing remote configuration of the different types of nodes (sensors, repeaters, and gateways). | Will be available under specific conditions: experiments to be carried out on top of it should pass a 'sanity test' to ensure they do not compromise the infrastructure itself. Deep technological knowledge is required. |
| Software applications | Basic applications for node configuration and management in order to be able to validate the operation of the system. Initial approach of first set of service oriented applications related to the management of the parking spaces. | Access to basic applications would be granted for experimentation purposes in case it is required. Applications for specific services being competence of the municipality not within the scope. |
| Innovation environments user communities | Currently not available. Will be addressed during the execution of the project, once the infrastructure is available, to involve third parties and end-users in the creation of services based on the sensors' data. | Will be available in the future, based on a Living Labs approach. The access will be limited to non-sensitive information to guarantee personal data protection, and prevent misuse of the information provided. |
| Sustainability and exploitation plan | Information of the outmost importance to describe the models considered within the project, with emphasis on those more suitable to guarantee the sustainability of the infrastructure. | The report analyzing potential exploitation models will be also publicly available through the project web-site at: http://www.smartsantander.eu. |
| Public data / information | A number of different information categories will be opened up to the public, to enable the use of applications, and the development of new ones. | Open APIs for accessing data will be made available at three different levels: research and developers' community, Service Providers (ISPs), and end-user. |

Table 2: SmartSantander project most important common assets

Apart from this, SmartSantander has a great potential to reduce time to market for new services, by shortening required R&D cycles, providing a fast end-user feedback for the assessment on socio-economic impact to the European researchers and service developers, and helping to make technology benefits more visible to the EU citizens. This is facilitated by the deployment of novel IoT solutions and application pilots on a realistic target environment involving real end-users. Besides, an early end-user exposure to the first applications and services based on IoT technologies can encourage its adoption and lower the boundaries of social acceptance by the public, which often acts as an inhibitor of technological advance.

By the time this paper was prepared, the first deployment phase has being carried out in Santander. By June 2011, most part of the first 2,000 sensors corresponding to the first phase of the project will have been deployed across the city. Using this preliminary approach to the final testbed, the project will issue the first Open Call to select proposal to be funded in order to run experimental research on top of it. At the same time, end-user perception with regard to the first services will be analyzed by means of surveys among the citizenship, and some services related to specific urban mobility use-cases will be further improved under a Customer Driven Innovation approach. These methodologies are also common to most Living Labs experiences. In the future stages of the project, and once the assets become progressively and publicly available, it is expected to involve wider communities in the usage of the infrastructure.

### 4.2 TEFIS: Future Internet experiments by combining different testbed resources

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

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

Two main types of assets are available via TEFIS for future Smart Cities experimentations: the platform and the testbed facilities provided by partners of TEFIS (Table 3). The TEFIS platform is organised into four main functional blocks: the portal, core services (middleware), testbed connectors and user tools. It offers different types of support for Future Internet experiments such as designing, planning, management of experimental workflow, configuration assistance, experimental data management, reporting, knowledge sharing with other experimenters and access to different testbed facilities and service offers independent of geographical location. The testbed facilities provided by testbed partners of TEFIS include a wide spectre of testing and living lab opportunities.

The following project case illustrates how in TEFIS resources are combined and shared. This specific Future Internet experiment is combining experimental resources from two different testbeds; the SQS IMS testbed in Spain and the Botnia Living Lab in Sweden. The experiment is focused on a mobile application over IMS, and is divided into three different phases of the service development life-cycle: concept development, prototype development and business model definition. First, this experiment will explore end-user feedback to check if the application is suitable and would be useful for users by access to Botnia Living Lab assets. In the second step, they will use the IMS-testbed facilities as a validation tool to perform system acceptance testing (including functional and non-functional), and Botnia Living Lab for usability evaluation with end-users. In the third step, they want to identify the correct business model for long-term sustainability. In this third phase both end-users feedback and network usage is monitored and analysed, and for that purpose the IMS testbed and Botnia Living Lab are combined.

| Asset type | Specification of the asset | Shareable asset |
|---|---|---|
| Network infrastructure (testbed facilities) | Planetlab: powerful infrastructure consisting of 1018 nodes for testing and evaluation of network protocols and distributed systems on a large scale.<br>PACA Grid: computing infrastructure for large-scale computations and various tools to automatically deploy and execute distributed applications and to monitor the progress of the computation and retrieve the results.<br>ETICS: build and test job execution system based on the Metronome software and an integrated set of web services and software engineering tools to design, maintain and control build and test scenarios.<br>SQS IMS: assets include the emulated IMS platform with IMS Core services, Presence and Group management, Push-to-talk, IMS Messaging, Instant messaging and Instant Multimedia Messaging, GSMA video/image share and enhanced VoIP and IMS Core Network emulator. Wizards and templates included in the tools are used for testing purposes.<br>KyaTera: High speed network of over 266 km of optical cables with 8 to 144 fibres and a network measurement tool to measure network status as bandwidth, jitter, delay, ping between two nodes, packet loss etc. | For sharing of these assets outside TEFIS, each Testbed facility provider has its own regulation for sharing and access to their assets. |
| Platform and Software applications | The TEFIS platform is organized into four main functional blocks: TEFIS Portal, TEFIS Middleware, TEFIS testbed connectors and TEFIS User tools. The User tools will be external tools, which could not be free, that the TEFIS platform can embed in a future next step | The TEFIS platform is being developed under the conditions of the Open License Terms. |
| Innovation environments user communities | Botnia Living Lab: Expertise in end-user evaluation and testing, the FormIT methodology for end-user involvement, a database of 6000 creative end-users in Sweden and access to end-users around the world via 3rd parties. | These assets are available to any user. Access is regulated depending on what kind of resources. Handbooks are available. |
| Sustainability and exploitation plan | Assets above provided via the different actors of TEFIS are in use today in internal cases and with external actors. Exploitation work is in progress on the networked offers for users of the facilities and for the TEFIS facility itself. A specific framework is used for the exploitation and sustainability processes. | Framework for business model creation, development and evaluation. |
| Public data / information | Depending on the users and each experiment data can be made public. At the minimum general information about each experiment is to be public available for knowledge sharing and visibility. | General information about each experiment using the TEFIS portal for their performance. |

Table 3: TEFIS Project Most Important Common Assets

### 4.3 ELLIOT: An Experiential Living Lab for the Internet of Things

The ELLIOT project (www.elliot-project.eu) aims to develop an IoT experiential platform where users/citizens are directly involved in co-creating, exploring, experimenting and evaluating new ideas, concepts and technological artefacts related to IoT applications and services. It intends to allow studying the potential impact of IoT and the Future Internet in the context of the Open User Centred Innovation paradigm and of the Living Lab approach within three different use cases. In this paper the focus is on the Green Services use case that constitutes a building block of environment monitoring in the Smart City. The Green Services use case has its origin in the living lab “ICT Usage Lab”, which is located in the South East of France and is run in the urban community of Nice Cote d’Azur (NCA). This Green Services use case is supported by local authorities and involves the local stakeholders such as the local institution for the measurement of air quality (AtmoPaca). Table 4 describes common assets for the Green Services use case.

| Asset types | Specification of assets | Shareable assets |
|---|---|---|
| Technologies and infrastructures | Fixed and mobile network of pollution sensors to collect environmental data.<br>The Green Watch: watch-embedded environmental sensors and noise sensors to collect positioning and environmental data;<br>The Sensor Vehicle: electric vehicles equipped with proper sensors to collect environmental data. | It is intended to open the access to collected environmental data to citizens and other stakeholders so that they could co-create their own services.<br>Information will be made available on the ICT Usage Lab web-site. |
| Software applications | Environmental data website such as ATMOPACA for air quality in the PACA region.<br>Green services web portal for supporting citizens driven services such as mobility services and wellbeing services | Both websites are intended to be publicly accessible.<br>Links will be included on the ICT Usage Lab web-site. |
| Innovation environments user communities | The ICT Usage Lab constitutes the multidisciplinary research and innovation ecosystem.<br>The ERIC (are Internet Regional Spaces for Citizen) local structure provides the user communities, which.<br>Citizen from a given neighbourhood as well as stakeholders in environment monitoring, urban mobility and health. | Access to local ICT Usage lab infrastructures and facilities such as Gerhome Lab, Webusage Lab, MyMed and FocusLab (under progress).<br>Access to ICT Usage Lab user communities will be available and limited to non –sensitive information to guarantee personal data protection. |
| Innovation and testing methodologies | Participative requirements techniques for supporting the creativity and requirements workshops.<br>User engagement, cyclic development, action research, data collection<br>Hybrid behavioural analysis method coupling a) usage and data mining and b) ethnographic and ergonomic study | Available on the ICT Usage Lab web-site. |
| Other assets (policy, funding, partnerships etc) | The impact on local policies and citizen behaviour change will be reported.<br>Partnerships and funding sources will be reported. | Will be made available on the ICT Usage Lab web-site. |
| Public data / information | Environmental data website such as ATMOPACA website for air quality in the PACA region.<br>Green services web portal for supporting citizens driven services such as mobility services and wellbeing services. | Open APIs for accessing data will be made available. |
| Capability to develop and run pilots | Develop and deploy Future Internet services projects within Nice Cote d'Azur (NCA). | Capabilities will be made available on the ICT Usage Lab website. |

Table 4: ELLIOT Green Services most important common assets

Citizens do not seem to feel so much concerned about air quality despite the availability of advanced models (AtmoPaca) which can produce reliable indicators as well as portals providing access to such measures. The main use of such data seems to be limited to population alert (elderly people, children and people with cardio-respiratory problems). The working hypothesis is that a citizen may better engage in the use (if not even in the creation) of green services (services using environmental data, in this case air quality and/or noise level) when being given the opportunity to learn and use IoT set-ups that will allow a better appropriation of the environmental data. The Green Services is supported by INRIA (Sophia Antipolis), Foundation for Internet New Generation (FING) and VU Log (France). The objectives of this use case are:

- To define within an open participative innovation process "green services" for citizens and city administrators in charge of air quality and noise disturbance. These green services will be based on the collection and processing of collected pollution data and will allow users to tailor their own information space about local pollution;

- To study the feasibility of a distributed mobile network of pollution sensors to collect environmental data;
- To study the impacts on citizens' behaviour and recommendations related to environment monitoring (e.g. pollution level).

Green Services are based on both fixed and mobile sensors (green watches and electrical vehicles) and supported by a green services portal. Types of mobile sensors used are the Green Watch (watch-embedded environmental sensors and noise sensors to collect environmental data) and the Sensor Vehicle (electric vehicles equipped with proper sensors to collect environmental data). Users involved in this Green Services testbed are citizen (citizen from a given neighbourhood, citizens with cardio-respiratory problems) and other environment monitoring stakeholders (such as local policy makers, environmental specialists and urban architects).

# 5 Towards Collaboration Models based on Living Labs and FIRE Common Assets

Based on the cases presented, this section aims to provide a framework for interested members from different Future Internet, Living Labs and Smart Cities communities to create collaboration models for sharing capabilities and resources offered by existing platforms, testbeds and living labs facilities. The framework proposes arrangements related to IPR management, legal issues and partnership agreements to implement an open innovation approach for transformation towards Smart Cities.

## 5.1 Common Assets Characterisation and Governance

The common assets to be made available to the members of the communities are of a different nature ranging from know-how, to software or user communities and thus require different business and legal arrangements and access mechanisms characterised as follows:

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

The Future Internet, Living Labs and Smart Cities Communities are creating a large amount of Common Assets, which they wish to make available to all communities. To support that goal, the basic approach suggested is to create a single catalogue, accessible for example through wiki pages that could be collectively edited (see Fig. 2). The advantage of this approach is the flexibility and the freedom of contribution that leaves the different constituencies to cooperate and share these assets without losing their independence. Each organization is responsible to update the description of its assets in the catalogue, using a wiki approach. All the shared assets will be included in the catalogue together with the information and the processes to access them. Each organization maintains its independence and any ownership rights are not affected by this process of virtual collaboration.

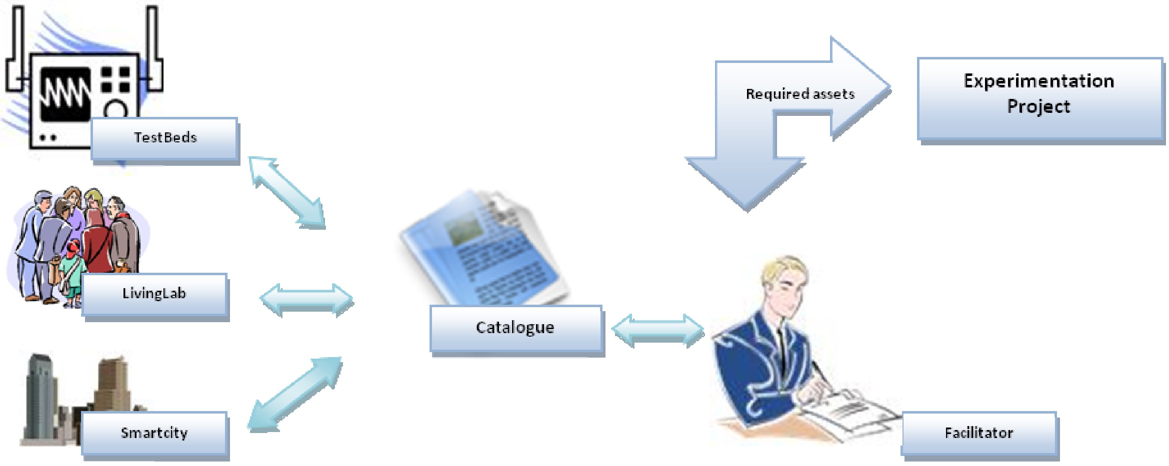


Figure 2: Logic of Common Assets Governance Model

The proposed governance structure is based on the well-established organisational forms of Collaborative Networked Organizations [Camarinha-Matos, Afsarmanesh, Ollus 2008]. Implementation of this governance structure could proceed through establishment of an open association of legal entities which would intend to favour the launch of Future Internet Experimentations projects in real life environments (i.e. pilots). Each member of this association would provide the description and access mechanisms for their owned assets. A proposed scheme for the legal framework and IPR management of the proposed association is currently in development in the FIREBALL project (www.fireball4smartcities.eu).

## 5.2 Cooperation Models Building on Open Access Mechanisms

Based on the cases and on mechanisms for access, sharing and governance of common assets, we seek to elaborate a simplified framework and typology of effective forms of collaboration to accelerate the development towards open innovation for “smart cities”. Two levels of collaboration can be distinguished; namely, strategic collaboration for setting up innovation conditions and operational collaboration for implementing innovation processes [Schaffers, Komninos, Pallot et al. 2011].

Strategic collaboration for open innovation is grounded on formal agreements regarding access to and sharing of common resources, as discussed in the former section. Additionally, such strategic collaboration requires sustainable partnerships or “business models” at the level of urban and regional development, including municipal and regional authorities, research institutes, societal institutions and companies. This approach can be found in SmartSantander.

Operational collaboration among Future Internet, Living Labs and Smart Cities initiatives and resources requires the definition of collaboration processes and infrastructures around a specific innovation opportunity. As an example, within TEFIS a simple sequential collaboration model has been elaborated for the purpose to serve an experimenter and to boost the usage of different assets from individual facilities as a unified service-offer to attract more users of the facilities and to be able to serve the fully service development life-cycle of a Future Internet service developer. In the first phase, Botnia Living Lab is used as a design tool facility. The second phase of prototype validation utilises functional testing capabilities of IMS facility (IP Multimedia System). The third phase of business validation builds on joint use and integration of the Botnia Living lab and IMS facilities. For Elliot, a more concurrent collaboration model is experimented (Fig. 3). An important challenge is to explore the different collaboration models and their effectiveness, which can be based on governance of common assets.

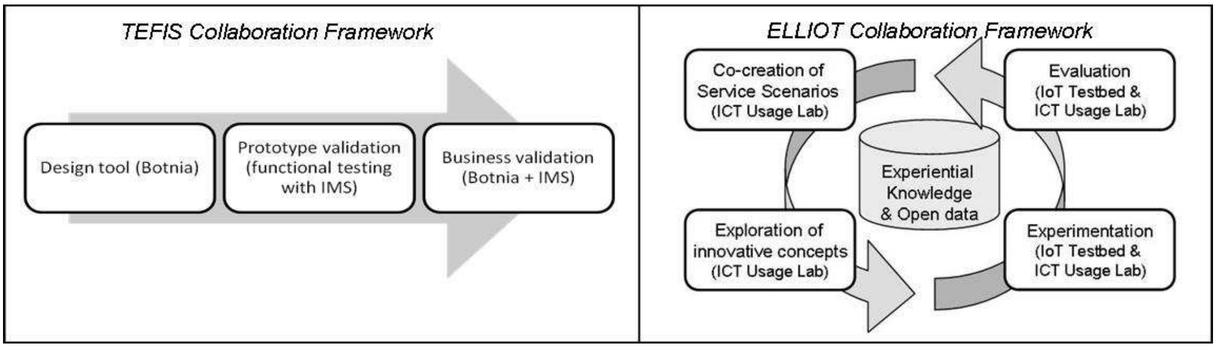


Figure 3: TEFIS and ELLIOT Collaboration Frameworks

# 6 Discussion and Conclusions

This paper explored the integration of living labs concepts with Future Internet and Internet of Things experimentally driven research approaches. On the one hand there is a clear need to enhance user involvement and user support in experimental research related to the Future Internet. On the other hand, open and user driven innovation such as in Living Labs often requires the access to testbed facilities and technical resources and capabilities. We therefore foresee an increasing need to create easy and context-specific access to common technical and non-technical resources and capabilities that can be shared for complex experimentation and innovation projects. To accomplish that goal to setup and operate such experimentation and innovation environments, issues such as technical access, access and sharing conditions, ownership and IPR should be resolved. The three cases show initial attempts to cope with these issues. We recommend that these cases are closely followed and evaluated. Follow-up work should extend these attempts to create mechanisms and bridge platforms for facilitating demand-driven experimental environments for Smart Cities and Smart Regions.

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**References**

Bergvall-Kåreborn, B., Ihlström Eriksson, C., Ståhlbröst, A., & Svensson, J. (2009) A Milieu for Innovation - Defining Living Lab. Accepted to the 2nd ISPIM Innovation Symposium, New York, December 6-9.

Camarinha-Matos, L., Afsarmanesh, H., Ollus, M. (2008) Methods and Tools for Collaborative Networked Organisations. Springer.

Caragliu, A., Del Bo, C. and Nijkamp, P. (2009) Smart Cities in Europe. Serie Research Memoranda 0048 (VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics).

European Commission, DG INFSO & Media (2010) Future Internet Research and Experimentation.

Institute for the Future (2010) A Planet of Civic Laboratories. The Future of Cities, Information and Inclusion.

Komninos N. (2008): Intelligent Cities and Globalisation of Innovation Networks. London and New York, Routledge.

Pallot, M, Trousse, B., Senach, B., Scapin, D. (2010): Living Lab Research Landscape: From User Centred Design and User Experience Towards User Co-creation. Position Paper, First Living Labs Summer School (www-sop.inria.fr/llss2010/), Paris, August 2010.

Schaffers, H., Navarro, M., Merz, C. Eds. (2010): Rural Development and Rural Living Labs. TRAGSA, Madrid.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., Oliveira, A. (2011) Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation. In: J. Domingue et al (Eds.): Future Internet: Achievements and Promises, Springer.