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Future Internet and Living Lab Research Domain Landscapes: Filling the Gap between Technology Push and Application Pull in the Context of Smart Cities

Marc PALLOT[1], Brigitte TROUSSE[1], Bernard SENACH[1],
Hans SCHAFFERS[2], Nicos KOMNINOS[3]
[1]*INRIA Sophia Antipolis – Méditerranée, AxIS Team, France*
Email: {marc.pallot, brigitte.trousse, bernard.senach}@inria.fr
[2]*ESoCE Net, Waterstraat 5, Zutphen, The Netherlands*
Email: hschaffers@esoce.net
[3] *URENIO, Aristotle University of Thessaloniki, Thessaloniki, Greece*
Email: Komninos@urenio.org

Abstract: While new paradigms such as Open Innovation [1] and Web 2.0 [2] as well as Living Labs operating as a User Centred Open Innovation Ecosystem [3] promote a more proactive role of users in the R&D process, a number of existing methods for involving users are described in the literature, such as Lead User [4], User Driven Innovation [4], User Centred Design [5] and User Created Content [1] as well as User Co-Creation [6]. Interestingly, the Internet evolves concurrently with research streams such as peer-to-peer, autonomous, content-centric and ad-hoc networking that have already demonstrated improvements on network performance and user experience. Peer-to-peer networking has demonstrated both the feasibility and economic potential for delivering services to millions of users. Cloud Computing is a more recent paradigm for transparently sharing among users scalable elastic resources over a limitless network. This paper explores the domain landscape of Living Lab and Future Internet research areas as well as the emerging Smart City landscape. It is believed that these landscapes provide valuable insights for articulating Living Labs between the technology push of Future Internet testbeds and the application pull of smart cities.

1. Introduction

Living Labs have the goal to involve users at the earlier stage of the R&D process not only as observed subjects but rather as a participative force for co-creating value. A living Lab is an open research and innovation ecosystem often based on a specific territory and involving a large diversity of stakeholders such as user communities (application pull), solution developers (technology push), research disciplines, local authorities and policy makers as well as investors. While the Living Lab ecosystem, through openness, multicultural and multidisciplinary aspects, conveys the necessary level of diversity, it enables the emergence of breakthrough ideas, concepts and scenarios leading to adoptable innovative solutions. A Living Lab empowers user communities like it is done with Web 2.0 [9].

A Living Lab allows enterprises, especially SMEs, and users/citizens either as entrepreneurs or communities to get access to technology infrastructure as well as science and innovation services. The main objectives consist to explore new ideas and concepts, experiment new artefacts and evaluate breakthrough scenarios that could be turned into successful innovations. The social dynamics of the Living Lab approach ensures a wide and

rapid spread (viral adoption phenomenon) of innovative solutions through the socio-emotional intelligence mechanism [10]. Living Labs are standing at the crossroads of different paradigms and technological streams such as Future Internet, Open Innovation, User co-Creation, User Content Creation and Social Interaction (Web 2.0), Mass Collaboration (i.e. Wikipedia), Internet Networking and Network Computing.

The Internet has progressively become a ubiquitous environment for globally communicating and disseminating information. There is a limitless amount of available online resources and tools to share information and develop a better understanding on whatever topics. With the recent advent of user created content, there has been a tremendous expansion in the number of web pages created every day for exposing and sharing societal issues such as environmental monitoring, energy efficiency, food and drug security as well as human well-being. The future internet will dramatically broaden both the spectrum of available information and the user's possible contexts and situations. This will lead to the vital need of a more efficient use of the Internet resources for the benefit of all. However, there are still open questions such as articulating the various relevant research streams for the Future Internet and for involving users within Living Labs and identifying appropriate concepts for supporting user co-creation in the context of Smart Cities.

The methodology used for developing both the Living Lab and Future Internet research domain landscape comprises a literature review for identifying the main domain concepts to be situated in the respective landscape, and metrics on the number of published papers for each domain concept (Google Scholar). The validation of the resulting landscapes was carried out through interviews of Living Labs and FIRE (Future Internet Research and Experimentation) projects.

2. Literature and Concepts

2.1 From Test and Experimentation Platforms towards Living Labs

Ballon and colleagues [11] found that Test and Experimentation Platforms (TEPs) constitute a new and relatively uncharted territory. Therefore, they launched an extensive exploratory research on TEPs theoretical literature and empirical data. They elaborated a domain landscape of TEPs with three different dimensions, namely technological readiness, balances in between testing and design (evaluation), the degree of openness. The different areas populating the landscape correspond to the six identified TEPs. They are positioned in the landscape according to the two dimensions of focus and technology maturity they are intended to deal with.

During the last decades the role of users in the R&D process has gradually evolved from lead user [4] towards user co-creation; see [6] and [3]. Pallot and colleagues [12] created a landscape of research and design methods involving users in R&D for getting a better understanding of the Living Lab research domain. This domain landscape is tentatively used as an evaluation tool for assessing the maturity level of 14 visited Finnish Living Labs [25]. While a domain landscape of design research was drafted in [7], in [8] it is argued that the notions of co-creation and co-design have been growing within the participatory design landscape. They proposes to involve active users by making use of generative techniques in order to practice more the concept of engaging users as co-creation contributors. They also state that co-creation necessitates sharing and collaboration, hence an open mindset that it not trivial to put in place.

2.3 Future Internet

The movement towards the Future Internet (FI) is based on the belief that the current Internet has reached his architectural capability and capacity limits [13]. The term "Future

Internet" represents worldwide research activities for re-inventing the Internet with better performance, reliability, scalability, security and privacy while keeping its key neutral principle as constantly recommended by Tim Berners-Lee.

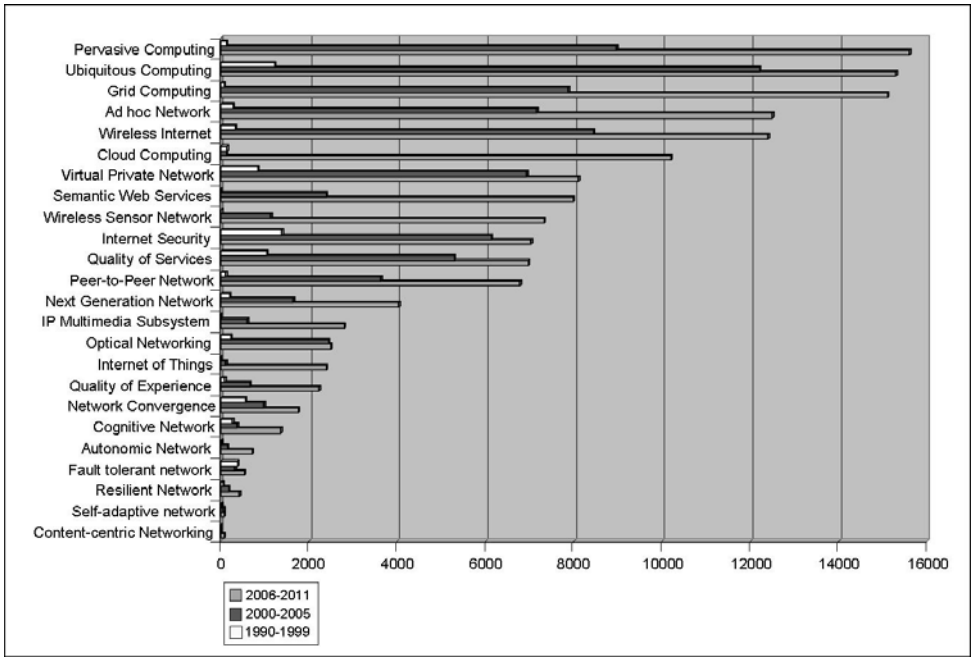

Figure 2: Publication Metric for FI Research Concepts

As shown in Figure 2, there is a great diversity of research streams and related topics for designing alternatives of the Internet of tomorrow. For example, the Internet of Things (IoT) is considered as a major research and innovation stream leading to create plenty of service opportunities in interconnecting physical and virtual worlds with a huge amount of electronic devices (e.g. sensors, actuators) distributed in houses, vehicles, streets, buildings and many other public environments. Hence, a massive amount of data will be flowing over the Internet that should not decrease the overall service performance and user satisfaction. FI represents the evolving need for infrastructures at the level of innovation infrastructure, and broadband Internet infrastructure. Obviously, FI will be the key driver of technological support for services and products to be explored, experimented and evaluated.

2.4 Smart Cities

As for intelligent cities, Komninos [14] analyses three different spatial models for creating environments of innovation, based on spatial proximity, learning institutions, and physical-digital innovation ecosystems. Komninos [15] explains the rise of intelligent cities with the integration of human intelligence of the population, collective intelligence of institutions for collaboration, and machine intelligence of digital networks. Many different kinds of applications were identified, related to cyber, digital, and smart city concepts [16] such as virtual cities, crowd sourcing, online collaboration, broadband for innovation, people-driven innovation, sensors, and smart environments to cite just a few.

In [17] it is foreseen the creation of a digital space over cities through four concentric rings (Figure 3) that does not spontaneously emerge, but rather comes from meticulous planning and development. They foresee a series of gaps which cities have to overcome such as, the digital skills gap that concerns the ability of citizens and companies to master web-technologies and offer solutions over the net; the creativity gap that separates web technologies and applications; the entrepreneurship gap that takes place between digital

applications and services. They recommend that cities have to experiment various business models and identify which are suitable for each type of service.

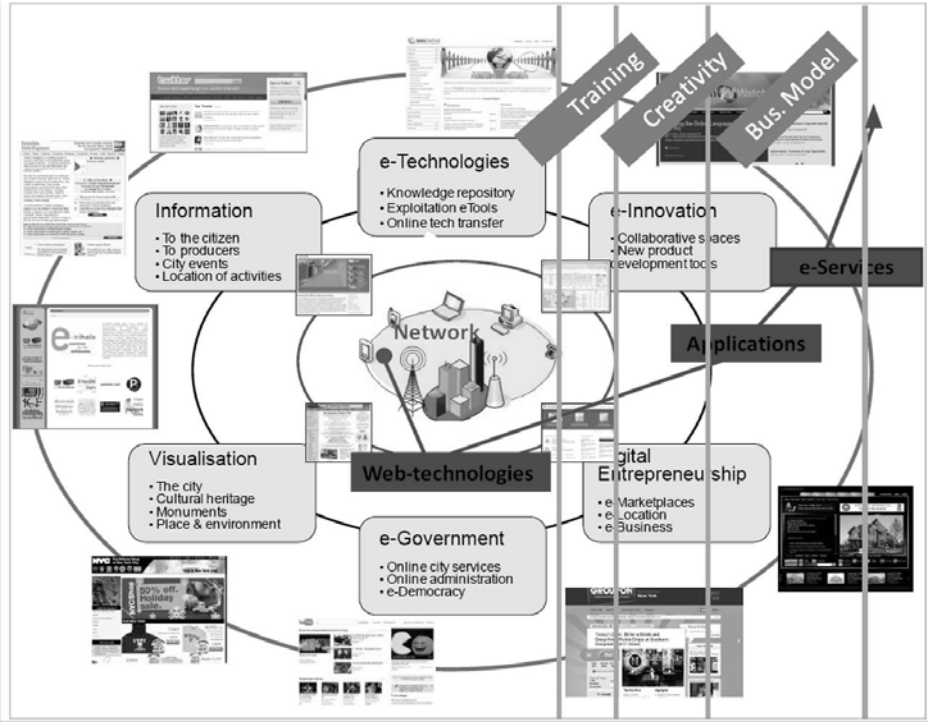

Figure 3: Digital Spatiality of Cities: Four Rings - Three Gaps [17]

Finally, they argue that Living Lab methodologies, social experiments, crowd sourcing, and open city platforms for creating and promoting applications may offer good solutions to this end and mobilize creativities of the entire population of the city. Living Labs for investigating and anticipating how FI technologies will change the way people live in the city and their implications at the urban dynamics (i.e. stigmergy, emergence). Hence, there is need for storing and exchanging data which are location and time-sensitive, making them accessible to users through smart devices, web interfaces and physical interface objects.

3. Designing a Living Lab Domain Landscape

Based on this idea of drafting a domain landscape on research and design methods for involving users in research and innovation, Pallot and colleagues [12] created a specific Living Lab research domain landscape (Fig. 4). The four dimensions are discussed in a previous paper [12] and described as follows:

- ***Interaction Mode*** illustrates the way interaction with users is perceived. This dimension scales from Human-Computer Interaction (HCI), which addresses individual users, to Interpersonal Interaction that embeds social interaction within a group of people.
- ***Research Type*** splits the domain landscape into Observation Research where a user is considered as a subject and Participative Research where users co-create value.
- ***Evaluation Focus*** starts with reliability, as a first stage, where a functional test is applied in order to check if a feature works properly. The second stage consists to carry on usability analysis for evaluating the user friendliness and ergonomic design. While the third stage "adaptability" brings the evaluation of personalisation, the fourth one "adoptability allows users to create new features in composing their own services.
- ***Collaboration Style*** scales from structure collaboration with for example Symbiotic collaboration style up to unstructured collaboration ([18], [19]).

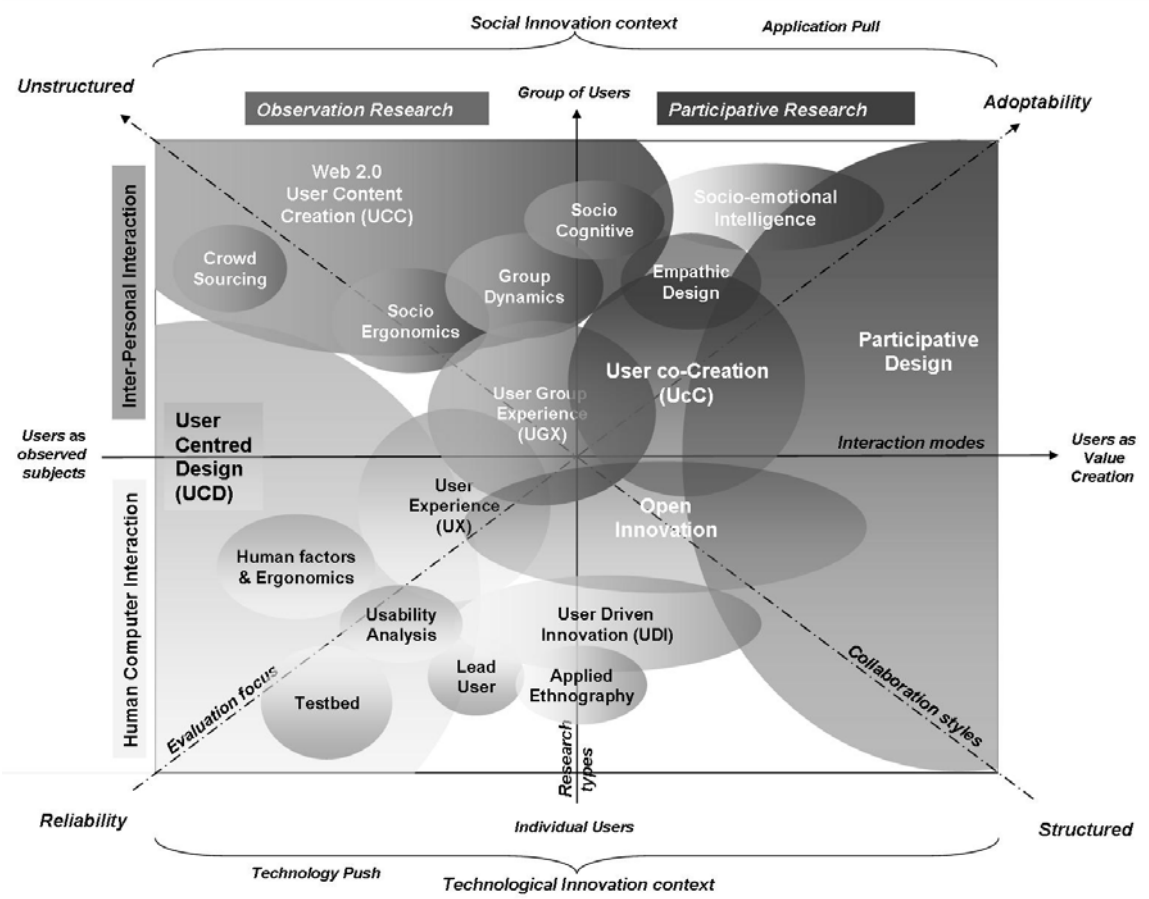

Figure 4: Living Lab Research Domain Landscape [12]

Technological innovation is included in the figure as corresponding to the HCI of the interaction dimension. Social innovation is also included in the figure as corresponding to the Interpersonal Interaction. The domain landscape map is then populated by existing research streams, such as User Created Content (Web 2.0 UCC) [20], User Centred Design (UCD), User Experience (UX) [21], User Group Experience (UGX) [22], Contextual Design [23], User Co-creation (UC), and User Centric-Innovation (UCI).

4. Future Internet Research Domain Landscape

Pallot and colleagues [24] believe that the proposed tentative landscape of FI research domain (Fig. 5) provides a faster and broader understanding of the different research streams and related topics. Several dimensions are discussed in a previous paper [24] and used for landscaping the Future Internet research domain, such as:

- ***Evolution approaches***: from incremental (evolution) design to Clean Slate re-design or radical evolution from where emerge new generation networks;
- ***Internet routing***: from the basic data packet delivery towards more sophisticated content distribution and retrieval capacities (content Centric Networking);
- ***Network Types***: from wired communication (cable or optical networks) to wireless communication networks (wireless Internet, wireless sensors networks);
- ***Evolution trends***: from a traditional computer network towards an autonomic and convergent network.

The Future Internet research domain landscape is divided firstly in a top and bottom spaces that respectively address the wired and wireless Internet, and secondly, in a right hand located space corresponding to the more traditional Computer Network territory and in a left hand space representing the more recent Network Computing territory.

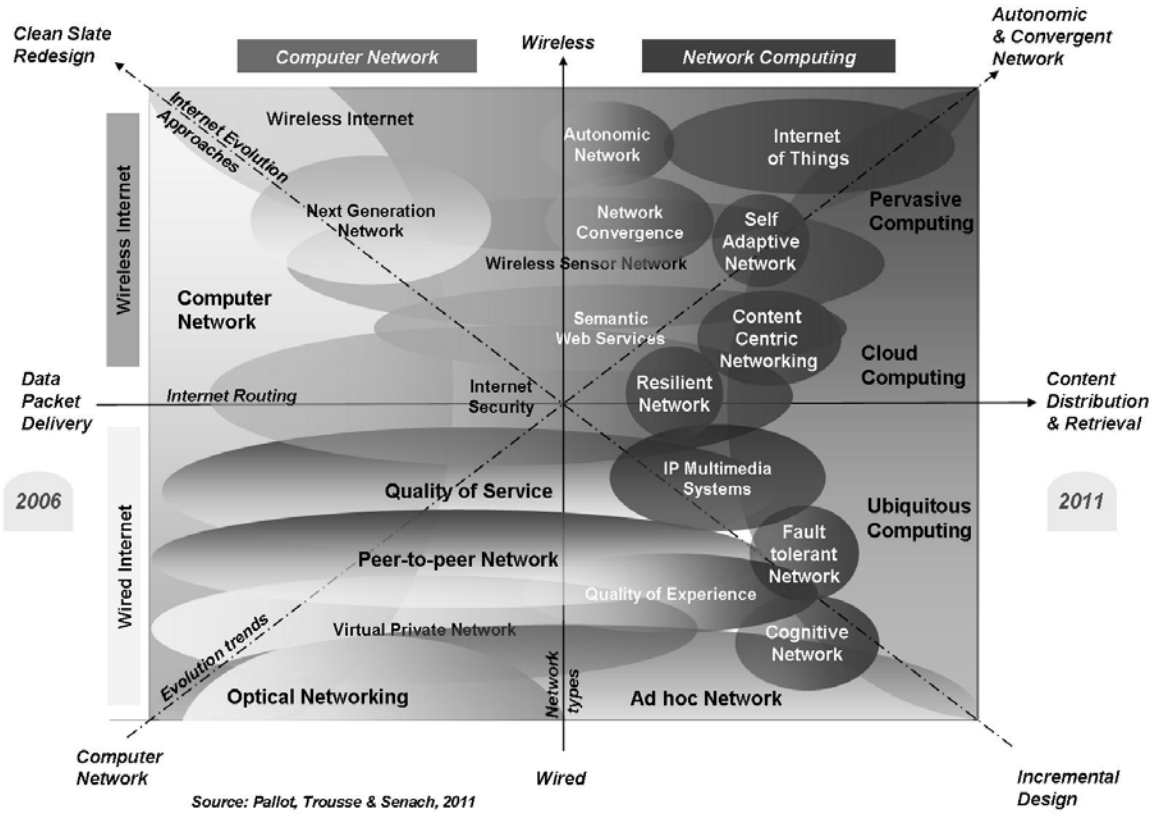

Figure 5: Future Internet Research Domain Landscape 2006-2011

In the landscape for the time period of 2006 - 2011 (Figure 5), each concept appears as a bubble whose size is proportional to the overall amount of published papers. The concept of "Computer Network" starts to decrease with a publication level of 18100 published papers. The opposite island, "Network Computing", increases with 6960 published papers. This might be highlighting the current transition from network computer towards network computing. The "Content-centric Networking" concept emerges in this period with 81 published papers. The most impressive progression comes from the concept of "Cloud Computing" that exponentially moves from 127 up to 10200 published paper in this period. The concept of "Internet of Things" moves in the same way but with a less exponential progression from 117 to 2400.

5. Emerging Smart City Landscape

The Smart City Landscape (Figure 6) covers key dimensions of the innovation systems of smart cities: technologies, applications, users and uses, methodologies, actors and policies [27]. 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, such as a map of technologies, map of city applications, and map of smart city policies. It is also important to describe the "vertical" relations across the layers.

The "landscape" covers the interconnected key dimensions of the innovation ecosystem of smart cities: technologies, applications, users and uses, innovation environments, actors and their policies. The landscape embodies a map of opportunities for integrated methodologies, stemming from future internet research and experimentation approaches

and living labs open innovation, as well as urban innovation policies, and for smart city innovations.

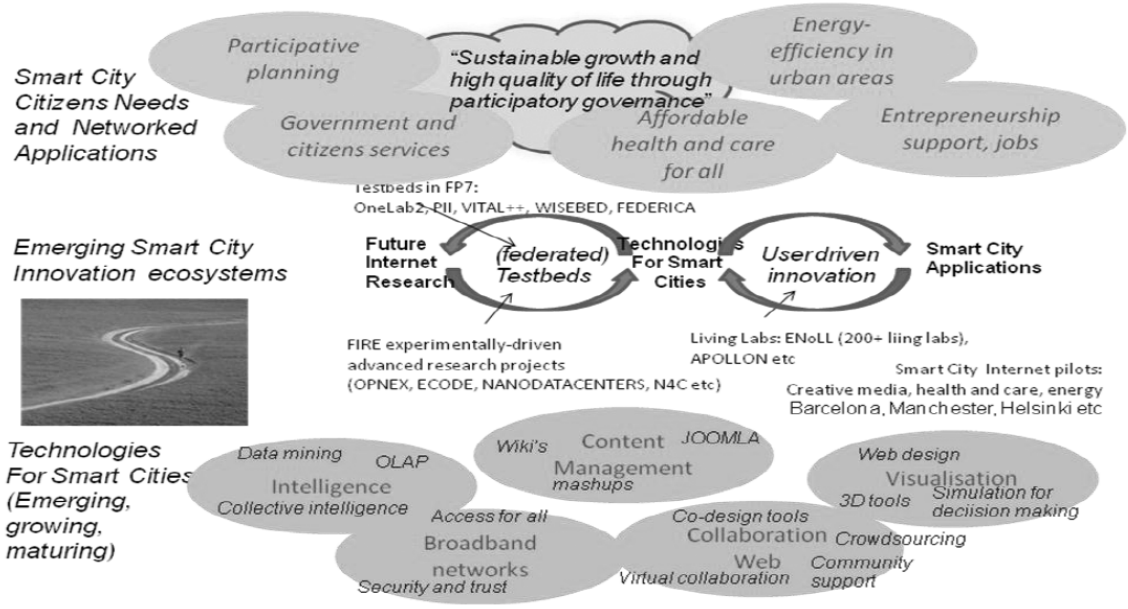

Figure 6: Emerging Smart City landscape

6. Conclusions

Technology push is still dominant in the actual research agenda. A recent Forrester survey states that smart city solutions are currently more vendor push than city government pull based. However, the survey points out that, "smart city solutions must start with the city not the smart" [28]. The positive impact of available smart city solutions on European cities has not yet been demonstrated, nor have the necessary funding mechanisms and business models for their sustainability been developed. The domain landscapes of Living Lab, Future Internet research and emerging Smart Cities appear to be a source of insights for researchers in filling the gaps between technology push and application pull. They also help to reach a broader understanding of the Living Lab movement towards more participative design for Future Internet and Smart City innovation ecosystems. In this context, the Future Internet represents the technology push, Smart Cities [26] represent the application pull and Living Labs form the exploratory and participative playground in between the FI technology and Smart Cities' applications. Future Internet research and experimentation represents a technology-oriented and longer term contribution. Cities provide a potentially attractive testing and validating environment. However, as shown above, a wide gap exists between the technology orientation of Future Internet research and citizens' expectations. Hence, the concept of open and user-driven innovation ecosystem, such as the Living Lab approach, brings the necessary combination level of digital skills, creativity and innovation methods that properly bridge the gap between technology push and Application pull. Finally, a roadmap towards Smart Cities, under refinement, will provide the necessary framework and methods for successfully connecting push and pull developments.

References

[1] Chesbrough, H. W. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology, Boston, Harvard Business School Press.
[2] O'Reilly T. (2005). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software, Retrieved January 2011 http://oreilly.com/web2/archive/what-is-web-20.html
[3] Pallot, M. (2009). The Living Lab Approach: A User Centred Open Innovation Ecosystem. Webergence Blog Retrieved January 2011 http://www.cwe-projects.eu/pub/bscw.cgi/715404

[4] Von Hippel, E. (1986). Lead users: a source of novel product concepts. Management Science 32, 791–805
[5] Von Hippel, Eric A. (2005). Democratizing Innovation, MIT Press, Cambridge, MA,
[6] Prahalad, C.K., Ramaswamy, V. (2000). Co-Opting Customer Competence. Harvard Business Review January 2000.
[7] Sanders, E.B., Stappers, P.J. (2008). Co-creation and the new landscapes of design. CoDesign, 4(1), 5-18.
[8] Mulder, I., Stappers, P.J. (2009). Co-Creating in Practice: Results and Challenges, Proceedings of the 15th International Conference on Concurrent Enterprising, ICE'2010 "Collaborative Innovation: Emerging Technologies, Environments and communities", Leiden, The Netherlands, June 2009.
[9] Frappaolo, C., Keldsen, D. (2008). What is Web 2.0?. Association for Information and Image Management. Retrieved January 2009 http://www.aiim.org/What-is-Web-2.0.aspx.
[10] Goleman. D. (2006). Social intelligence: the new science of human relationships. Publisher: Bantam Books. Publication Date: September 2006. ISBN-13: 9780553803525.
[11] Ballon, P., Delaere, S., Pierson, J., Poel, M., Slot, M., Bierhof, J., M. Diocaretz (2005). Test and Experimentation Platforms for Broadband Innovation: Conceptualizing and Benchmarking. International Best Practice. IBBT/VUB-SMIT Report.
[12] Pallot, M., Trousse, B., Senach, B., Scapin, D. (2010). Living Lab Research Landscape: From User Centred Design and User Experience towards User Cocreation. In Proceedings of the Living Lab Summer School, Paris, Cité des Sciences, August 2010.
[13] Tselentis, G., Galis, A., Gavras, A., Krco, S., Lotz, V., Simperl, E., Stiller, B., Zahariadis, T. (2010). Towards the Future Internet - Emerging Trends from European Research. Retrieved from http://www.booksonline.iospress.nl/Content/View.aspx?piid=16465
[14] Komninos, N. (2002) Intelligent Cities: Innovation, knowledge systems and digital spaces, London and New York: Taylor and Francis.
[15] Komninos, N. (2008) Intelligent Cities and Globalisation of Innovation Networks, London and New York: Routledge.
[16] 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", The Future Internet, Lecture Notes in Computer Science, Vol. 6656, pp. 431-446.
[17] Komninos, N., Tsarchopoulos, P. (2012). Intelligent Thessaloniki: From Agglomeration of Apps to Smart Districts. To appear in Journal of Knowledge Economy Special Issue "Smart Cities and the Future Internet in Europe".
[18] Dorigo M., Stützle T. (2004), Ant Colony Optimization, MIT Press, 2004. ISBN 0-262-04219-3
[19] Elliott, M. (2006). Stigmergic Collaboration: The Evolution of Group Work. *M/C Journal* 9.2. 21 March 2009. Retrieved March 2009 http://journal.media-culture.org.au/0605/03-elliott.php
[20] Garrett, J. 2002, Elements of User Experience: User-Centered Design for the Web. New Riders Press.
[21] de Ruyter, B., van Loenen E., Teeven, V. (2007). User Centered Research in ExperienceLab, European Conference, AmI 2007, Darmstadt, Germany, November 7-10, 2007. LNCS Volume 4794/2007, Springer.
[22] Fleming, J. 1998, Web Navigation: Designing the User Experience. O'Reilly & Associates, Inc, USA.
[23] Beyer, H., Holtzblatt, K. (1998). Contextual Design: Defining Customer-Centered Systems. San Francisco: Morgan Kaufmann. ISBN: 1-55860-411-1.
[24] Pallot, M., Trousse, B., Senach, B. (2011). A Tentative Design of a Future Internet Research Domain Landscape. INRIA AxIS internal report.
[25] Salminen, J., Konsti-Laasko, S., Pallot, M. (2011). Evaluating User Involvement within Living Labs through the use of a Domain Landscape. Proceedings of the 17th International Conference on Concurrent Enterprising, ICE'2011, Aachen, Germany, June 2011.
[26] Schaffers, H., Santoro, R., Sällström, A., Pallot, M., Trousse, B., Hernandez-Munoz, J. M. (2011). Integrating Living Labs with Future Internet Experimental Platforms for Co-creating Services within Smart Cities. Proceedings of the 17th International Conference on Concurrent Enterprising, ICE'2011, Aachen, Germany, June 2011.
[27] Schaffers, R., Sällström, A., Komninos, N., Pallot, M., Trousse, B.,Senach, B., Hielkema, H. (2011). Landscape and Roadmap of Future Internet and Smart Cities. Fireball Deliverable D2.1.
[28] Schaffers, H., Pallot, M., Komninos, N. (2011). Smart Cities Challenges for Future Internet and Living Labs. FISA Roadmapping, May 2011. Retrieved: http://www.ami-communities.eu/pub/bscw.cgi/639128