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From Web 2.0 to Living Lab: an Exploration of the Evolved Innovation Principles

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Abstract—Living Lab is an emerging user-centric innovation approach and has been widely used to facilitate ICT innovations. Although there are many definitions for it from different perspectives, a holistic view is still forming. This paper explores a set of Living Lab innovation principles by extending the Web 2.0 principles proposed by O'Reilly. Furthermore we test these principles against two Living Lab cases. This paper contributes by providing a holistic view towards Living Lab and the evolution from Web 2.0 to Living Lab.

Index Terms—Living Lab, Web 2.0, Innovation principle, ICT

I. INTRODUCTION

The importance of users in innovation process has been recognized by scholars for quite a long time [1], [2]. This has been manifested more clearly with the rise of Web 2.0 phenomena with numerous user-generated contents such as Wikis and Blogs. Users are empowered by different Web 2.0 services to make their contributions.

With the continuous progress in Information and Communication Technologies (ICT) such as ubiquitous computing, mobile computing and Web of Things (WoT) [3], the boundary of Web 2.0 phenomena has been expanded from Web to the real life contexts. Users' everyday life activities and experiences have been increasingly digitalized by intelligent devices, sensors and mobiles [4]. The potential of users in innovation process has greatly increased as users are empowered by more devices (e.g. sensors and smartphones) and more services (e.g. mobile and ubiquitous services).

There are growing numbers of user-centric innovation approaches with the increasing roles and potentials of users in innovation [5]. Among them, an emerging innovation approach called "Living Lab" (LL) has generated wide interest in both academia and industry. The concept

of LL was introduced by Professor William Mitchell from MIT MediaLab and School of Architecture and city planning [6]. The original idea of LL was to construct a home-like smart environment by ambient intelligence and ubiquitous computing technologies such as wireless and sensor technologies to sense, prototype and validate complex ICT solutions [5]. Examples of this kind of LLs include the Aware Home at Georgia Institute of Technology [7] and PlaceLab at MIT [8]. Later, the concept has been extended to a more general user-centric innovation approach in which ICT innovations are co-created, tested, and evaluated in open, multi-party collaborative, multi-contextual real-world settings [5]. Many examples of this kind of LLs are listed in The European Network of Living labs (ENoLL, www.openlivinglabs.eu).

As a comparatively new concept, there are no universally accepted definition for LL yet. Many different definitions from different perspectives have been proposed during the years. For example, LL has been defined as an environment [9], [10], methodology [11] and system [12]. There are also some attempts to identify the key elements and characteristics of LL such as [6], [12]. However, a holistic view towards LL is still forming [13]. Historically, there are also fragmented views towards Web 2.0, which has been seen as software, services, community and business model [14]. However, the seven principles of Web 2.0 proposed by O'Reilly are still the best way to comprehensively understand it [14]. By the same token, we argue that in order to get the holistic view of LL, it's important to understand the principles of LL.

Although LL and Web 2.0 are in different domains, they are both emerging innovation phenomena and approaches. From innovation principles' perspective, we find that there are many similarities and evolutionary relationships between Web 2.0 and LL with development of ICT and user roles. However, little research has been done to explore the connection between LL and Web 2.0.

Therefore, the purpose of this paper is to fill the

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mentioned LL research gaps and contribute in two ways. First, it provides a holistic view to LL. Second, it explores the connection between LL and Web 2.0 or how current LL concept evolves from Web 2.0 in different dimensions.

The remainder of the paper is organized as follows. In Section II, a comparison between the Web 2.0 principles and the evolved LL principles is presented. Section III tests the evolved LL innovation principles by two LL projects cases. Section IV discusses the findings, limitation and future work. Finally, Section V concludes the paper.

II. FROM WEB 2.0 TO LIVING LAB

In this section, we detail the comparison between the seven widely accepted Web 2.0 principles by O'Reilly [15] and our extended work-in-progress principles of LL. The extended principles of LL are based on existing LL literature and our own many years of LL research and practice experiences [16].

A. Principle 1: Web as a platform vs. Living Lab as an innovation ecosystem

A Web 2.0 service is a combination of software and data or Software as a Service (SaaS) [15]. In SaaS mode, the software is no longer traditional packaged software, but exists as web services. From innovation's perspective, Web 2.0 is not much technical innovation but new ways of using existing technologies. For example, a key component of Web 2.0 "Ajax" (Asynchronous Javascript and XML) is built on existing web technology (Javascript) and standard (XML). Many Web 2.0 services are web mahups which are innovative ways of integrating existing web services and data sources [17]. In Web 2.0, Web becomes a programmable innovation platform (cf. www.programmableweb.com) instead of passive data repository as in Web 1.0 .

The evolution from Web 2.0 to LL is shown in Fig. 1. LL innovation expands the first Web 2.0 principle in several ways. First, although both Web 2.0 and LL are networked innovation, the network boundary of LL has expanded from Web to real life contexts by using enabling technologies such as ubiquitous computing and Web of Things (WoT). Therefore, the services and data sources for innovation have expanded. Second, the stakeholders in innovation have expanded. Web 2.0 is a grassroots (community) innovation, while LL is a more complexed innovation ecosystem involving many different stakeholders such as business, research institutes, developers, government and end users or a Public Private Partnership (PPP) [6]. Third, the complexity of innovation has increased. Because of the network expansion (e.g. more devices in LL innovation such as sensors) and stakeholder expansion, the complexity of innovation also increased in LL innovation as the increasing efforts to integrate more heterogeneous devices and to coordinate the collaboration between different stakeholders.

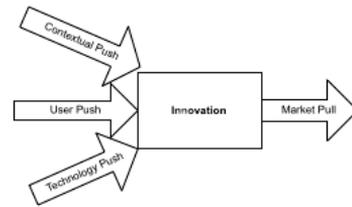


Figure 2. Innovation forces (adapted from [18]).

B. Principle 2: Harnessing Collective Intelligence vs. Adding new innovation force "Contextual Push"

Harnessing collective intelligence is the main principle of Web 2.0 [15]. Other similar phrases to collective intelligence are the wisdom of crowds and the 'long tail' effect. The examples of this principle include Google PageRank, Flickr tagging and Amazon reviews. Essentially, it means utilizing the network effects from user contributions or user added values. Specifically, Web 2.0 services are designed to utilizing the implicit contributions from a large number of ordinary users as opposed to explicit contributions from a small number of leader users [14].

Although users are still in the central position in LL innovation, the drivers of innovation in LL innovation have expanded by adding a new innovation force — the "Contextual Push" as shown in Fig. 2 [18]. Traditional innovation forces include the technology push and market pull. The rising of user-driven innovation, community innovation (e.g. Web 2.0) adds a new innovation force — user push. The key difference between LL and other user-driven innovation approaches is that it emphasizes the innovation from contextual push in users' real life contexts, which can discover the needs which users are not explicitly aware but emerge from the contexts.

C. Principle 3: Data is the Next Intel Inside vs. Experience is the Next Key Aspect

In Web 2.0, the companies who control the data can gain key advantages in the market, which also reflects that data is one of the main purposes of computing in Web 2.0.

In LL, the main purpose of computing is experience instead of data. Early LL research built a home-like experiential environment by sensors and intelligent devices. With the further development of ICT technologies such as WoT and mobile computing, the four dimensions of people's everyday life experiences (time, space, actors and artifacts) have been increasingly digitalized [4]. The focus of LL is to obtain ICT innovation sources from people's experiences in real life contexts and innovate ICT solutions to make better life experiences for people. Many scholars argue that the computing paradigm will shift from data to experience [4], [19].

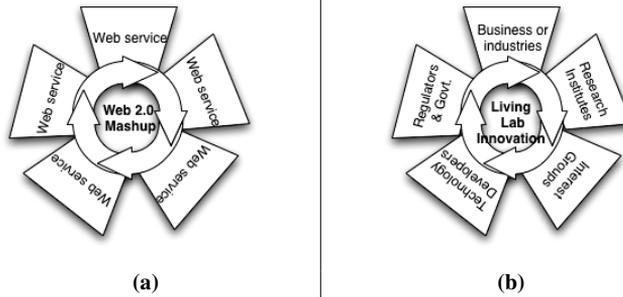


Figure 1. Evolution from Web 2.0 to Living Lab: (a) Web 2.0 (b) Living Lab .

D. Principle 4: End of the software release cycle vs. End of innovation cycle

In Web 2.0, software shifts from artifact to service which need to be maintained continuously. For example, Google must continuously crawl the web to update its indices. Thus, there are no traditional software release cycles for Web 2.0 services. Users are treated as co-developers. New features are quickly added to or removed from services by real time monitoring of user online behaviors. Web 2.0 services often exist in “the perpetual beta” development status [15].

With the increase of ubiquity and pervasiveness of ICT technologies such as ubiquitous computing and mobile handset-based monitoring, the real time and large scale monitoring of user behaviors in real life contexts become feasible and affordable. Users’ living contexts become ubiquitous “laboratories”. LL research is conducted by continuously monitoring users’ behaviors in their daily activities and experiences over a medium or long period [9]. Users are treated as co-partners (e.g. co-developers and co-researchers) as shown in Fig. 3. Empowered by ICT tools such as self-monitoring tools, visualization and statistics tools, users can do some kinds of research work (e.g. collecting and analyzing data), which are the privileges of researchers in the past. In addition to the meaning of research in real life contexts, LL may also suggest that innovation often exists in continuously ongoing status. Innovations (new products, services and knowledge) are emerged by the continuous interaction between the stakeholders or players such as users, developers and researchers [20].

E. Principle 5: Lightweight programming models vs. Dual innovation models

Web 2.0 services are web services built on top of lightweight programming models such as RSS (Really Simple Syndicate), REST (Representational State Transfer) and Ajax instead of more complexed corporate web services models such as SOAP (Simple Object Access Protocol). This benefits the services reuse and boost grassroots innovation for the low technical barriers [15].

From innovation’s perspective, Web 2.0 is a bottom-up grassroots or community innovation model. There are also top-down innovation models such as the classical

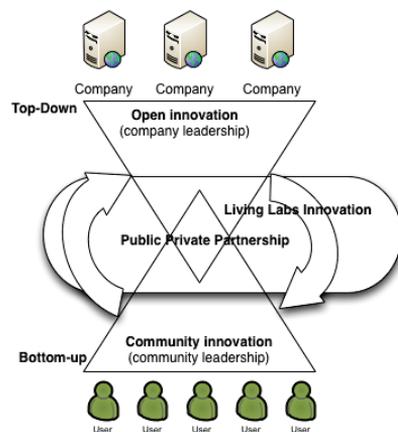


Figure 4. Dual model for open innovatin, community innovation and Living Lab.

manufacture centric closed models and open innovation models [21]. In closed models, innovations are created in a R&D (research and development) unit or its equivalent [22]. In open innovation models, companies harness both external ideas and in-house R&D [21]. The closed innovation models and open innovation models are both company-leading top-down models.

LL is a bridge or intermediary between open innovation and community innovation [13]. It’s commonly known as a Public Private Partnership which integrates concurrent research and innovation processes [23]. Based on this and the idea of dual model which integrates business and grassroots [24], [25], we propose a dual model to illustrate the intermediary role of LL between open innovation and community innovation as shown in Fig. 4. On the one hand, LL provides structure and governance to user participation for companies [26]. On the other hand, LL provides company supports such as financial and technical supports to communities [16].

F. Principle 6: Software above the level of a single device vs. Experience above the level of a single context

Web 2.0 services are no longer limited to the PC platform. They can be accessed by heterogeneous devices

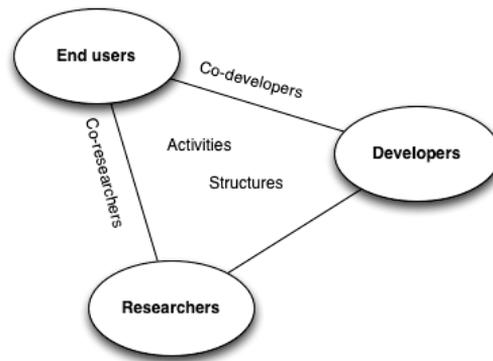


Figure 3. The model of Living Lab approach (adapted from [20]).

such as PCs, Mobiles and Tablets. Web functions as a virtual single device for users, which provide users seamless services access [15].

However, in Web 2.0, computing is still separated from users' other daily activities and experiences, while in LL, it is seamless embedded in everyday life experiences and contexts. Therefore, LL functions as a virtual single context for users, which provides users seamless services experiences. The similarity between Web 2.0 and LL is illustrated in Fig. 5. Figure 5 shows that Web provides uniform access interface to heterogenous devices, while LL offers consistent experience for different contexts.

G. Principle 7: Rich user experiences vs. Real user experiences

Web 2.0 services provide users richer service experiences by using technologies such as Ajax [15]. However, as we said in the previous subsection, Web 2.0 service experience is still separated from other forms of human daily experiences such as shopping and traveling, while the core of LL is to provide users seamless real life experiences in different contexts. The principle of realism (real users in real life situations) is also what distinguishes LL from other kinds of user-centric innovation approaches [27].

III. CASES

In order to test the principles described in Section II, we will walk them through with two different LL innovation projects cases: OtaSizzle and SmartBUPT.

A. OtaSizzle(O)

OtaSizzle is a long-term mobile social media LL research project in Finland Aalto University. It aims to develop an open experimentation environment for testing mobile social media services and promoting user-driven mobile social media services innovation and study [16], [28].

B. SmartBUPT(S)

SmartBUPT is an Internet of Things (IoT) LL research project in Beijing University of Posts and Telecommunications (BUPT). It aims to create an open campus innovation platform to facilitate users to create useful and intelligent services in their daily campus lives [16].

C. Testing the principles against the cases

P1: LL as an innovation ecosystem

- O: There are different stakeholders in OtaSizzle project such as students, companies (e.g. Nokia and Elisa) and researchers. Different stakeholders collaborate for mobile social media innovation [28].
- S: There are different stakeholders in SmartBUPT project such as students, companies (e.g. Terra-IT) and researchers. Different stakeholders collaborate for IoT innovation [16].

P2: Adding new innovation force "Contextual Push"

- O: In OtaSizzle project, mobile handset-based measurement and context-aware mobile questionnaire tools are used to discover user behavioral patterns during daily interactions with mobile social media [29].
- S: In SmartBUPT, there are many kinds of sensors (e.g. temperature sensors and infrared sensors) deployed in campus context to find new innovation sources.

P3: Experience is the next key aspect

- O: The aim of OtaSizzle is to study the user behaviors and improve user experiences in mobile social media [28].
- S: SmartBUPT creates a smart IoT environment in campus to study students' everyday

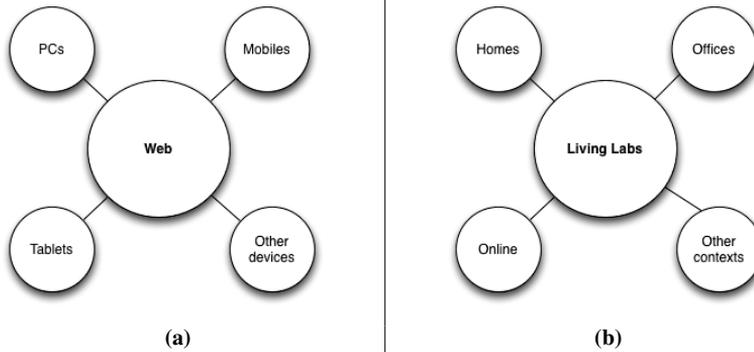


Figure 5. Similarity between Web 2.0 and Living Lab: (a) Web as a single device (b) Living Lab as a single context .

life activities and experiences and promote innovations in IoT area [16].

P4: *End of innovation cycle*

- O: User behaviors are studied by traditional focus group interview [30], server logs and mobile handset-based measurement [29]. Users are not just research subjects but also co-developers and co-researchers empowered social media services, monitoring tools, visualization and statistics tools.
- S: User behaviors are monitored by different sensors such as temperature sensors and infrared sensors deployed in the campus. Users are provided both web tools (e.g. Google map based visual sensor platform) and mobile applications (e.g. mobile widgets) to check the collected data [16].

P5: *Dual innovation models*

- O: OtaSizzle has pure grassroots innovations and innovations which combined grassroots innovations and companies and other organizations innovations (<http://sizl.org/>).
- S: SmartBUPT has grassroots innovations such as mobile applications developed by students and innovations combined grassroots and companies (e.g. Terra-IT) innovations [16].

P6: *Experience above the single context*

- O: OtaSizzle has already partly replicated its mobile social media services infrastructure and end user services to other international Sizzles sites such as BeijingSizzle, NairobiSizzle and CalSizzle. It aims at an ambitious goal to study different experiences above the single Sizzles context [16].
- S: SmartBUPT first uses campus as a test base. Later, it will extend to other collaborating universities and society.

TABLE I.
THE EVOLUTION FROM WEB 2.0 TO LIVING LAB

Principle	Dimension	Web 2.0	Living Lab
P1	Network boundary	Web	Real life contexts
P2	Innovation Driver	User Push	Contextual Push
P3	Computing Paradigm	Data	Experience
P4	User roles	Co-developers	Co-partners
P5	Innovation model	Bottom-up	Dual
P6	Connection	Devices	Contexts
P7	Feature	Rich experiences	Real experiences

P7: *Real user experiences*

- O: OtaSizzle studies real user experiences of students by interacting with social media in their everyday campus lives [16].
- S: SmartBUPT studies students' real everyday campus behaviors and experiences by IoT technologies [16].

IV. DISCUSSION

In Section III, we evaluate the extended seven LL innovation principles by two different LL projects cases in different areas. The cases support the extended principles quite well. We summarize the expansion or evolution from Web 2.0 to LL in the Table I.

From Table I, we can see that LL innovation expands from Web 2.0 innovation in many different dimensions such as network boundary and user roles. Compared with Web 2.0, LL is a wider and deeper level of innovation approach which integrating more devices, stakeholders and disciplines. This also makes it more difficult to scale up LL to macrolevel [26]. The challenges are not only technical but also can be commercial, legal and political. For example, in our early international LL project collaboration experiences, many challenges to scale up LL to international contexts actually are not technical but legal and political such as privacy and security issues [16].

We acknowledge the limitation of the evaluation of principles by just two LL cases. In future work, we will do a more comprehensive literature reviews on LL innovation projects and test the principles by them.

V. CONCLUSION

Web 2.0 innovations has manifested the roles of users as a co-producers and co-developers. With the continuous progress in ICT technologies, LL innovations are the natural extension or evolution from Web 2.0 innovations. In this paper we explore the principles of LL innovations. We evaluate the proposed the principles by two LL innovation projects cases. This paper contributes by providing a holistic view of current fragmented views towards LL innovations and exploring the evolution from Web 2.0 to LL.

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