Internationally Distributed Living Labs and Digital Ecosystems for Fostering Local Innovations in Everyday Life

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***Abstract*— There are an increasing number of information sources and services around us enabling new ways of interacting with our everyday environment. Examples include intelligent devices, sensors embedded in the environment and the emerging Internet-of-Things. Simultaneously users are becoming increasingly involved as information providers and consumers by means of Web 2.0 and social media. While these areas have gained a lot of attention recently and while the research on Digital Ecosystems has also dealt with these phenomena separately there seems to be need for research on the rich and complex ecosystem combining the sensor-based information sources with Web 2.0 and mobile services. In this paper, we propose a Digital Ecosystem architecture, which combines the social media and Internet-of-Things. The architecture is the fruit from the international collaboration between two long-term university Living Lab projects in Finland and in China. It aims at fostering student innovations in their everyday campus lives. We discuss the experiences learnt in the context of this international collaboration and the implications to Digital Ecosystem research.**

***Index Terms*— Living Labs, Digital Ecosystems, Internet of Things, Ubiquitous Computing, Web of Things, Social Media**

I. Introduction

With the rapid development of Information and Communication Technology (ICT), digitization has entered into nearly every aspect of people's lives such as entertainment, e-business, e-learning, e-government and e-health. There is an increasing number of information sources and services around us enabling new ways of interacting with our everyday environment in work, at home and in leisure activities. Examples include intelligent devices, sensors embedded in the environment and the emerging Internet-of-Things (IoT). Simultaneously users are becoming increasingly involved as information providers and consumers by means of Web 2.0 and social media. Around these phenomena, some emerging research concepts and research fields have become popular such as Digital Ecosystem (DE), Living Lab and Experiential Computing, which will be explained in more detail in the related research subsection.

In this paper, we describe the development of an internationally distributed DE research environment aiming at providing a Living Lab type of innovation platform for studying the combination of the "intelligent environment" and the users and their activities. Specifically, we describe the underlying architecture of the environment for enabling research in service creation and use over long periods of time in real-life settings.

A. Related Research

a) Digital Ecosystem: The origin of DE concept is related to the concept of Digital Business Ecosystem (DBE) , which was first proposed in Europe as a response to how the European Union could assist the SMEs (Small and Medium Enterprises) to adopt ICT technologies more effectively to improve productivity [1]. Nachira defined DBE as " a 'digital environment' populated by 'digital species' which could be software components, applications, services, knowledge, business models, training

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modules, contractual frameworks, laws, ..." [1]. The DBE is the combination of technical or digital part (Digital Ecosystem) and business part (Business Ecosystem) [2]. The DBE definition emphasizes the perspective of business.

There are many different emerging definitions for DE. For example, Briscoe and Wilde define DE as "the digital counterparts of biological ecosystems, which are self-organizing and scalable architectures that can automatically solve complex, dynamic problems" [3]. This definition views DE from architecture perspective. Chang and West define DE as "an open, loosely coupled, domain clustered, demand-driven, self-organizing agents' environment, where each specie is proactive and responsive for its own benefit or profit" [4]. This definition views DE from environment perspective. For the purpose of this paper, we view DE as a technical architecture.

Many emerging DEs have been studied recently. For example, Karhu et al. study a DE where users use Web 2.0 tools to develop new web services [5]. Lawson et al. study a virtual museum DE implemented as Web 2.0 applications [6]. Briscoe and Marinos study the DE from Cloud Computing's perspective [7]. Innocenti et al. study the DE of a digital preservation system [8]. These studies approach DE from the perspectives of Web 2.0 and Web services.

On the other hand, with the development of sensors, RFID (Radio-Frequency Identification), wireless networks and other enabling technologies, more and more devices and artifacts in daily life such as washing machines and coffee machines have computing and communication capabilities and become new digital species in ICT networks. There is also a lot of research on sensor-based systems in DE area. For example, Mostefaoui and Piranda study the architecture of a multimedia sensor network [9]. Zatout et al. study a hybrid wireless sensor network architecture for monitoring people at home [10]. Liu and Roantree study a precomputing query method for personal health sensor environments to overcome the inefficiency of XML query languages [11].

However, the research to combine the sensor-based systems with Web 2.0 and social media and studying the combination from the ecosystem perspective appears to be scarce.

b) Living Lab: The Living Lab concept was initially developed by Prof. William Mitchell, of the MIT MediaLab and School of Architecture [12]. According to the statistics of ENoLL (European Network of Living Labs) website, Living Labs are getting increasing momentum all over the world [13]. During its rapid growth, it has been defined as an environment [14], a methodology [12], [15] and a system [16] for innovation. Although different definitions view Living Lab from different perspectives, two common emphasis points are the central roles of users in innovation and the importance of real-life contexts or living environment of users for innovation. In this paper, we see Living Lab both as an environment and a methodology depending on the context of discussion. We define Living Lab as a user-centric and multi-party collaborative R&D methodology or environment where innovations such as new services are created and validated in multi-contextual real-life environment within individual regions [12], [14].

c) Experiential Computing: Traditionally, computing is separated from other forms of human activities and focuses on organizations and business [17]–[19]. With the ubiquity and pervasion of ICT and digitization by sensors, embedded computing, mobile computing and social computing, a new computing paradigm called "experiential computing" has emerged [17]. Experiential computing is defined as "digitally mediated embodied experiences in everyday activities through everyday artifacts with embedded computing capabilities" [19]. There is a lot of call for more research on experiential computing [17], [19].

B. Research Motivation

First, we illustrate the relationships between the aforementioned three emerging research concepts: DE, Living Lab and Experiential Computing in Fig. 1.

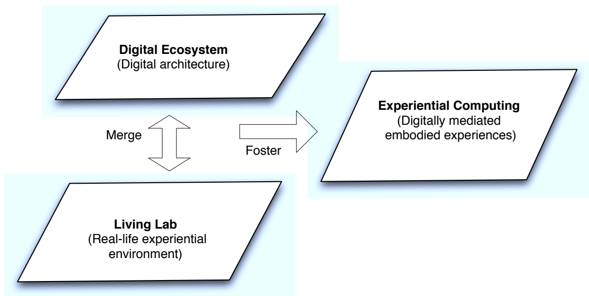

Figure 1. The relationships between Digital Ecosystem, Living Lab and Experiential Computing

DE provides a scalable and self-organizing ICT technical architecture [3], while Living Lab provides a rich experiential environment for data, information and innovation sources [12]. We believe that the combination of DE and Living Lab will foster experiential computing and innovations in everyday life experiences.

As we mentioned in the previous subsection, though there are a lot of DE research on Web 2.0 and sensor-based applications, the study to combine these two parts seems to be scarce. The paper aims at filling the gap in DE research and also responding to the call for more research on experiential computing. We describe a joint research effort carried out by researchers in Europe and China on campus-based Living Labs for studying the combination of ubiquitous and mobile social media services. We propose a DE architecture enabling easy use of the information sources in the environment for locally and situationally relevant services and for collection of quantitative and qualitative data on the use of the services in people's daily lives.

The key contribution of this paper is by mapping the concepts of Living Lab, social media (Web 2.0 services) and ubiquitous services (sensor-based services) in the context of internationally distributed DE research.

C. Structure of the paper

The rest of the paper is organized as follows: First, we introduce the background and current status of the two Living Lab research projects in Finland and in China in Section II and Section III respectively. Section IV presents the DE architecture design and implementation of the ubiquitous campus Living Lab innovation platform. Section V discusses what we have learned in the process of the international project collaboration and the implications of our work to DE research and future work. Finally, Section VI concludes the paper.

II. Living Lab and Social Media—OtaSizzle Project

A. OtaSizzle Project Background

Social media such as Wikipedia, Facebook, Twitter and YouTube have become more and more popular in people's digital lives. According to Hitwise, an online trends and analysis website, Facebook surpassed Google Search as the most visited site in US on the week ending March 13, 2010. The popularity of social media has attracted a lot of academic and industrial researchers all over the world to study this phenomenon. It's worthwhile to note that similar developments in social media are taking place also among the extensive Internet and mobile user population in China. For example, the mentioned social media services have Chinese equivalents that are rapidly expanding: Twitter—Sina Weibo, YouTube—Tudou and Youku, as well as the several local Facebook type of services.

With the development of 3G networks and smart phones, social media are increasingly being accessed by mobile clients or browsers. Mobile social media are new focal research areas for researchers. However, although there are already a great many of social media services such as Facebook and Twitter in the market, the data in existing social media services are mostly proprietary and controlled by companies. Therefore, access to relevant data is a major challenge for researchers when studying mobile social media [20]. The aim of OtaSizzle project is not to compete with the existing social media services, but to provide an environment that is designed and well instrumented for supporting research. According to the project Wiki, "OtaSizzle will develop an open experimentation environment for testing mobile social media services. It will be a 'living lab' for thousands of users in Otaniemi, with extensions in greater Helsinki. The project will create prototype mobile social media service platforms and study them with extensive field tests, coupled with quantitative measurements and qualitative analysis. The outcome will be a "packaged" experimentation environment, "SizzleLab" concept" [21].

B. Current Status of OtaSizzle

The OtaSizzle platform includes core services and end user services. The core services provide some common services such as user profiles, user groups, session management, location information and social networks that are shared by all end user services. End users can keep the same accounts and their social relationships among all end user services. Some core services are provided by the project. For example, the ASI (Aalto Social Interface, http://cos.sizl.org) service is social networking web service built with Ruby on Rails. Some core services are provided by third-party services providers such as the geolocation and localization services provided by OpenNetMap (www.opennetmap.org). On top of the core and enabling services, end users can create many kinds of mobile and Web-based social media services [22]. The end user services can be created by different programming languages such as Ruby, Java, PHP and JavaScript. The communication between the core services and the end user services is based on RESTful (REpresentational State Transfer) HTTP request and response [23]. The overview of OtaSizzle project architecture is shown in Fig. 2.

Currently there are five end user services listed in the Sizl portal (www.sizl.org). Later, all the end user services and applications will be listed in a dedicated marketing place—Aalto Apps. Among the five end user services, Ossi (https://ossi.sizl.org) is a group-centered mobile social media service oriented to high-end mobile phones such as Nokia N97 and iPhone. In Ossi, users can connect with friends, create new groups, join existing groups and initiate discussions [22]. The user interface of Ossi is shown in Fig. 3.

Figure 3. Ossi mobile social media service interface

Kassi (http://aalto.kassi.eu/) is an online resource exchanging social media service. In Kassi, users can post what goods and services they can give and what they need [24]. Currently, Kassi can only be accessed by browsers in computers. Mobile version is under active development. The home page of Kassi is shown in Fig. 4.

NordSecMob (http://nsm.sizl.org/) is practical information sharing social net-working service for NordSecMob (Master Program in Security and Mobile Computing) student community [24]. It can be accessed by computers and mobile phones.

Unlike the Ossi, Kassi and NordSecMob which are developed by the OtaSizzle project, AaltoLunch

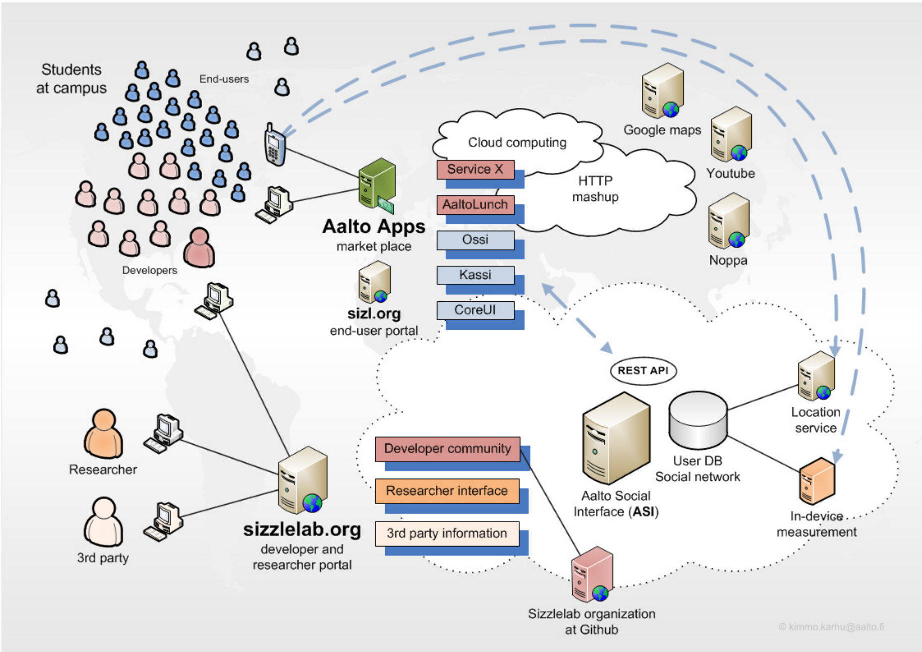

Figure 2. OtaSizzle architecture (adapted from [22])

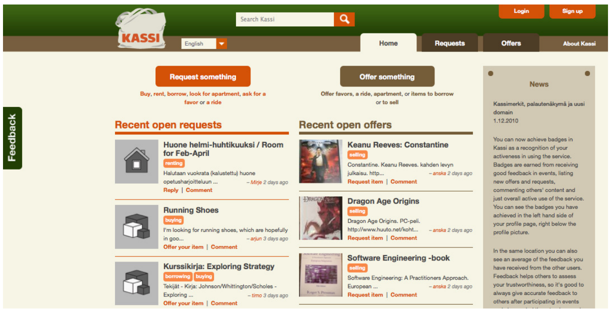

Figure 4. Kassi social resource exchange web service

(http://www.aaltolunch.fi) is the first end user service innovated by students in Aalto University. It's a mobile service providing daily menus of student restaurants on all three Aalto University campuses, in which users can also share their lunch plans with their friends.

The aforementioned four end-user services have been all developed by OtaSizzle project and student teams in Aalto University. An example of external service that has been linked to OtaSizzle environment is the Mobile Hubi (http://m.hubi.fi/mobi/). It is the first external service (developed by VTT, the Technical Research Center of Finland) to join OtaSizzle via the ASI. It provides context-aware services such as public transport route guide and Helsinki area event recommender.

All core services and end user services developed by the project or student teams in Aalto University have been open-sourced under the MIT open source license. The source codes are hosted in the Github (http://github.com/sizzlelab).

It should be noted that the above services themselves are just seeds for further development. The core services and related research tools are among the key elements of OtaSizzle project. The environment and experiments are being partially replicated in China (BUPT, Beijing), in US (UCBerkeley) and in Africa (University of Nairobi) for carrying out comparative studies on the development and use of target services.

The Smart BUPT and joint UBISERVE work, described next, provides complementary services for including sensors, intelligent environment and IoT approach, forming a joint basis for the DE research environment described in this paper.

III. Living Lab and Internet of Things—Smart BUPT Project

A. *Smart BUPT Project Background*

According to ITU (International Telecommunication Union) Reports in 2005, Internet of Things (IoT) is conceptual vision of future Internet where anything can be connected anywhere at anytime by using enabling technologies such as GPS (Global Positioning System), RFID and sensors. Since the proposal of IoT concept, Chinese government has considered it of great importance for research and development and several initiatives have been launched in that area. One of the active Chinese universities in mobile and IoT research is BUPT (Beijing University of Posts and Telecommunications). Smart BUPT project, focusing on IoT research, aims at creating an open campus based innovation platform by combining IoT and Living Lab approaches to facilitate user-driven creation of useful and intelligent services related to their daily activities. In order to lower the technical threshold for users to create mobile ubiquitous services, Smart BUPT project architecture is more based on the concept

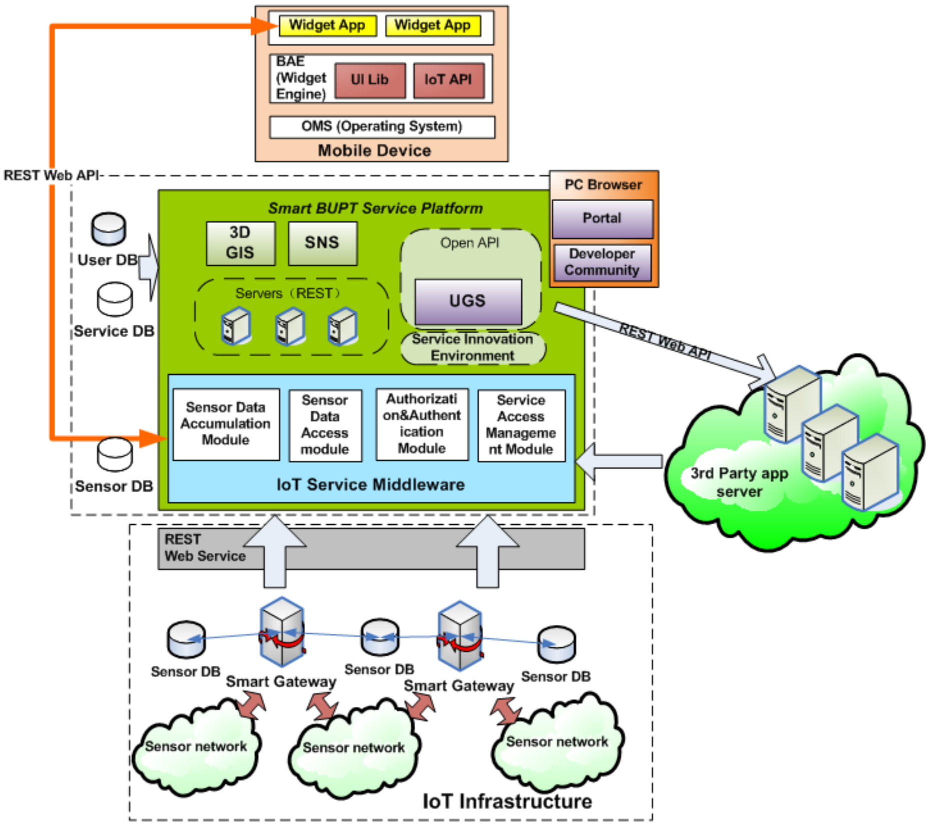

Figure 5. Smart BUPT architecture

of Web of Things (WoT). Similar to the concept of IoT, WoT is based on the vision that everyday devices and objects are connected and fully integrated to the Web by using existing well-accepted Web standards such as HTTP and REST [25]. End user services use Mobile Widget technology which is also based on popular Web technologies such as HTML, CSS and Javascript. The Smart BUPT project architecture is shown in Fig. 5.

B. Current Status of Smart BUPT

Currently, there are three end-user mobile widget applications based on the sensors (temperature sensors and infrared sensors).

One service example is the temperature warning system in which students can check the current temperature and temperature history in the monitoring points such as dormitories. Automatic warning messages will be sent by the system if the temperature in the monitoring points is higher than the given thresholds. Fig. 6 shows the mobile widget end user interface of the temperature warning system.

Another service is the dressing index where students can input their demo-graphic information such as gender, age, weight and height. The system will suggest students what kind of clothes to dress at particular monitoring points such as classrooms. Fig. 7 shows the mobile widget user interface of dressing index service.

The last end user service of the current three sensor-based mobile widget services is the seat occupation rate service, in which students can check the current situation of seat occupation rate (for example, whether the classroom is fully occupied or still seats available) based on the infrared sensors near the doors of monitoring points such as classrooms and library.

Figure 6. Temperature warning system

There is a RFID-based sub project called Smart Library under the Smart BUPT project, in which students and faculty can use their mobile phones to trace the location of a book by its RFID tag in the library. Another service example that combines location information and 3D maps is called 3D campus navigation. It is based on GPS and GIS technology developed by Terra-IT (http://www.terra-it.cn) company.

Again, the aforementioned services are meant as seeds

Figure 7. Dressing index service user interface

and examples, and the key area of the activity is to develop the infrastructures and environment for long-term research in real-life settings with support for situationally and locally relevant services as in the case of the OtaSizzle counterpart but with special emphasis on enabling use of sensor-based information sources and IoT approach.

IV. UBISERVE: A FUTURE UBIQUITOUS INNOVATION PLATFORM

A. *Motivations for the combination of OtaSizzle and Smart BUPT*

According to Yoo, people's everyday experiences can be conceptualized as the interactions with four dimensions: time, space, actors and artifacts as shown in Fig. 8 [19].

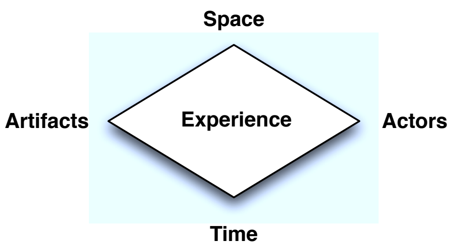

Figure 8. Schematic Framework of Experiential Computing (from [19])

From the perspective of experiential computing, experiential computing is enabled by the mediation of all or part of the dimensions of the aforementioned four dimensions of human experiences through digital technology [19]. For example, according to Yoo, the digitization of physical artifacts can be realized by RFID, sensors and IoT. The digitization of actors has been accomplished partly by the proliferation of social networking sites and social media [19].

From the perspective of DE, Nachira et al. believe that DE is made possible by the convergence of three networks: ICT networks, social networks and knowledge networks [2].

Based on these perspectives, we believe that the combination of the OtaSizzle (focusing on social media) and Smart BUPT (focusing on IoT) is important for both experiential computing research and DE research. The complementary relationship between the projects is shown in Fig. 9. From Fig. 9, we can see that current OtaSizzle project focuses on the combination of Living Lab and social media (the network of people), while Smart BUPT project focuses on the combination of Living Lab and Internet of things (the network of things). The combination of these three parts is the ubiquitous Living Lab service platform—UBISERVE.

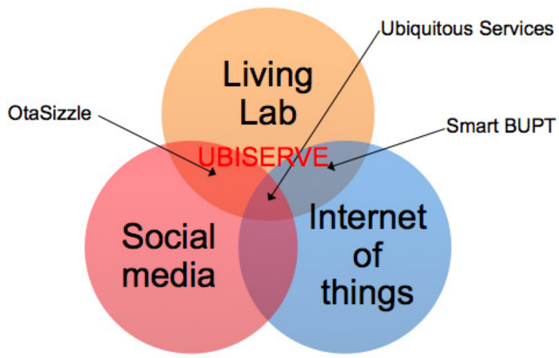

Figure 9. Complementary relationship between the projects

The UBISERVE project (Research on Future Ubiquitous Services and Applications) is "a joint research effort funded by Finland Tekes (the Finnish Funding Agency for Technology and Innovation) which is dedicated to advance research in the field of Future Ubiquitous Services (FUS). The project will strength the collaboration between Finland and China in ICT Alliance through constructing service enabling environments, developing test environments for FUS in real-life settings. The activities include living-labs based research on ubiquitous innovation and constructive research on transmission algorithms and service overlay architectures" [26].

The similarities between OtaSizzle project and Smart BUPT project are as follows:

- Living Lab approach
  - Both are based on Living Lab idea and mobile services platform.
  - Both are first deployed in campus environment.
- Technical similarities
  - Their architectures are similar (layered and modular). There are core services libraries and different end user services.
  - The core services libraries such as OtaSizzle ASI and Smart BUPT sensor libraries are both written by Ruby on Rails.
  - The calls between end user services and core services is by RESTful APIs.
  - Both have location-based services.
- Ecosystem thinking
  - Both are open platforms which provide open APIs to third-party developers.
  - Both are supported by partnering with third-party companies.

Based on the similarities and complementary relationship between OtaSizzle and Smart BUPT, we propose a new campus-based ubiquitous Living Lab innovation platform, which will be described in the next subsection. The main purposes and motivations of the platform are as follows: a) creating of a campus-based environment for creating and studying locally and situationally relevant mobile social media services; b) making use of information sources related to the local environment (sensors, e.g. temperature), context (e.g. location), users own input (e.g. observations/comments) and local information services (e.g. various campus based services) ; c) supporting local service innovation by combining social media and sensor-based services; d) providing a platform for better understanding social networks, user behaviors, and system interactions across different cultures and with likely very different underlying infrastructure and social contexts.

B. Architecture of the Ubiquitous Living Lab Innovation Platform

The architecture of the ubiquitous Living Lab innovation platform is shown in Fig. 10. It is the combination of Living Lab environment and DE architecture. Therefore, we divide the architecture into two parts: Living Lab environment part and DE architecture part. In the Living Lab environment part, we focus on the actors such as end users and developers and their roles in the ecosystem. In the DE architecture part, we focus on the digital species and technical architecture that combines the social media and sensor-based services from original OtaSizzle and Smart BUPT architectures. The architecture is described in three blocks. The leftmost block is developers block. The rightmost block is the researchers block. The middle block is the DE architecture. Above these three blocks, The topmost part is the end users.

1) Living Lab Environment: There are different types of actors or players in the Living Lab environment. They are self-organizing and related to each other and maintain the ecosystem collaboratively. Specifically, the actors in the ecosystem are as follows.

a) End users: The main end users are students in campus. But this group of actors also include faculty and staff in university as well as the local citizens. End users are not only services consumers and testers but can also act as services co-creators. Their needs and requirements in their daily activities and their experiences are the sources for new services and innovations.

b) Developers: End user services developers — They develop all kinds of end user services based on the core and non-core services. They can be project developers, students and third parties.

Core services developers — Core service developers can be project developers such as ASI developers and third parties such as OpenNetMap. They provide DE foundation services for end user services developers.

Third-party services providers — Third-party services providers have different roles in the architecture. Some third-party companies are project sponsors. For example, Nokia company sponsors a batch of N97 mobile phones for OtaSizzle. Elisa company sponsors free bandwidth for OtaSizzle. External entities and companies can be seen as providers of both core services, such as OpenNetMap, and non-core and end user services, such as Facebook and Mobile Hubi. Some companies provide services for researchers, such as Zokem company (http://www.zokem.com/) who provides handset-based data collection and measurement for OtaSizzle user research.

c) Researchers: Researchers carry out constructive and empirical research such as service design and implementation, and studies on service usage, adoption and diffusion, carrying out measurements and user behavior analysis in different cultural contexts. Developers support researchers by the development of research tools and facilities such as Ressi. Ressi is a Web-based research tool for researchers to view and download research data in the databases and visualize user activities. On the other hand, such research helps the development of better services for the DE based on research findings and insights.

2) Digital Ecosystem Architecture: The middle block is the DE architecture block. In order to illustrate the combination of OtaSizzle (social media part) and Smart BUPT (IoT part), we use different colors to represent components from OtaSizzle and Smart BUPT respectively. Specifically, in the architecture, the components related to OtaSizzle social media are filled in white, while the components related to Smart BUPT IoT are filled in dark gray. If a component is filled in white with dark gray shadow, this means that both OtaSizzle and Smart BUPT architecture contain this component. Examples include the third-party services or this components based on the combination of components from both projects such as the new end user services built on top of both OtaSizzle and Smart BUPT core services.

The DE architecture block contains three sub-blocks or layers. The bottom layer is third-party services networks and sensor networks. Third-party services networks include campus services such as the online course registration service and library service and other third-party company services such as Facebook and Google Maps. The sensor networks include smart objects (sensors, RFID) and wired/wireless networks deployed in the campus areas. Different services and data sources such as sensor data can be combined to create a new service by Web mashup—a Web application that integrates services and data from multiple sources to provide a unique service [27].

The middle layer is the core services layer. The core services include the social network service such as ASI, the sensor-based services and third-party core services such as OpenNetMap service.

The top layer is the end user services layer. The end user services can be built on top of core services and third-party services. Some end user services per se also provide RESTful APIs such as the Kassi service and can

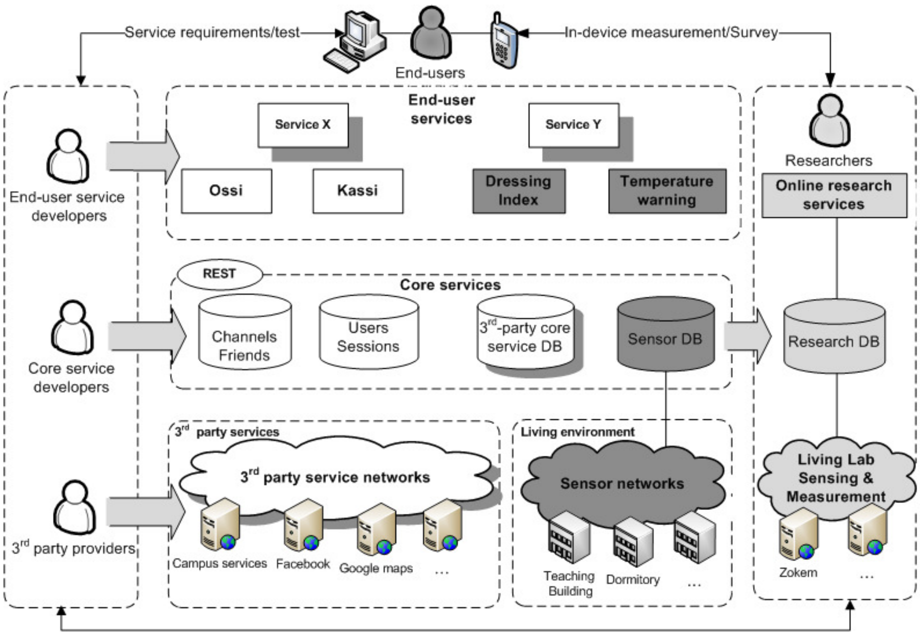

Figure 10. Architecture of the ubiquitous campus Living Lab innovation platform

be the sources for further mashups. In the future, we will also have end user services built on top of OtaSizzle and Smart BUPT core services.

V. Discussion

A. What we have learned in the international project collaboration?

Internationally distributed project collaboration is usually challenging, especially in the different cultural contexts like Finland and China. The collaboration between OtaSizzle and Smart BUPT has progressed quite well. For example, the OtaSizzle ASI and Kassi services have been deployed and adapted at BUPT. Next, we summarize the factors we believe to have contributed to this. Also, we recognize the need of future work in development joint methods and tools for comparative studies, and in gaining better understanding on how to take the different regulatory and cultural contexts into account when carrying out long term user studies enabled by linking the environments and research activities.

a) Open source: Nachira et al. believe that open source approach is the only possible choice for the DE infrastructure [2]. To facilitate academic research and international collaboration, the simple and flexible license type—MIT license was chosen for OtaSizzle project. MIT license is less restrictive than GPL license and thus more business friendly.

b) Common core services technologies: Both OtaSizzle social media core services and Smart BUPT sensor-based core services are built on the common software technologies (e.g. Ruby on Rails). Therefore, it is much easier for the integration and improvement of core services of both projects.

c) Simple and lightweight service development and mashup technologies: The RESTful APIs provided by OtaSizzle services, Smart BUPT services and mobile widget development technologies can lower the technical barriers for service development and mashups.

d) Effective collaboration and communication tools: Github has been chosen for project source code management and coordinating distributed development. For communication, Email, Skype and Flowdock are used. Regular Skype conference calls between the developers in Finland and China every two weeks are carried to check the current status and the next steps. While common in distributed software development, these settings are also beneficial for distributed research collaboration.

e) Focus on local needs and situations: Unlike Facebook which provides the same service globally, the purpose of OtaSizzle and Smart BUPT services is to satisfy the local and situational needs. For example, the OtaSizzle services in Nairobi University have been adapted to SMS-based services to gear to the poor mobile infrastructure there.

f) The power of social media in marketing services: Social media provides important channels for services marketing. For example, based on the Google Analytics that was set up for OtaSizzle services such as AaltoLunch, Facebook has quickly surpassed Google search and the aforementioned Sizl portal to be the most important channel for students to find the service.

B. Implications to Digital Ecosystem Research

The main implications of our work to DE research are as follows: a) we combine the three emerging research concepts: DE, Living Lab and Experiential Computing by applying the DE architecture in the internationally distributed Living Lab environment to foster local innovations in everyday life experiences; b) we integrate the two complementary aspects, i.e. mobile social media and ubiquitous (IoT) services for DE architecture in the real-life settings. The integration is particularly well suited for having campus-based environment as a research basis; c) we focus on the locality aspect, namely the locally relevant aspects that tie the services to the area and activities (e.g. campus area and activities) and to the physical environment. There is potential service innovation and even development community that can be actively involved both in the use and in the creation of new services in the "miniecosystem of campus" and the interlinking campuses; d) we are developing the basis for multi-contextual/multi-cultural DE studies by linking the Living Labs in Europe/Finland and in China/Beijing with option of others like Africa/Nairobi and US/California, which provides rich academic research opportunities for DE.

C. Future Work

For the future work, we are integrating OtaSizzle social media core services with Smart BUPT sensor libraries. We will have joint code camps to develop some new end user services based on these core services and other services such as campus services. We are currently conducting similar and comparative user surveys in UCBerkeley, Nairobi University, Aalto University and BUPT. Later, we will have joint research experiments and comparative studies of mobile use and development. We will collect some comparable datasets for user behavior study (e.g. handset based measurement and analysis using Zokem's mobile clients, using server side logging, situational surveys, etc.).

VI. Conclusions

In this paper, we combine three emerging research concepts: DE, Living Lab and Experiential Computing. We propose a DE architecture for ubiquitous campus Living Lab innovation platform based on the international exchange and collaboration between two Living Lab research projects in Finland and in China. The DE architecture is designed by combining two complementary aspects: social media and ubiquitous sensor-based services in real-life settings. The implications of our work to DE research have been discussed. We hope our work will inspire other researchers to join the effort and build a platform together that enables truly collaborative DE research.

Acknowledgment

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- Telepresence
- Lifelong Integrated Learning
- Smart Environments
- Web 2.0 and Social intelligence
- Context Aware Ubiquitous Computing
- Intelligent Brokers and Mediators
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