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Abstract: Advancements of intelligent transportation technologies and ICT have enabled new possibilities for improving attractiveness and efficiency of public transportation services, which is instantly needed for solving constantly growing challenges of urban transportation due to the global population growth and urbanization. A multitude of new technological possibilities and simultaneously limited resources for developing, testing and selecting the best solutions have created a need for service platforms enabling fast development and efficient operation in cooperation with various organizations. This article identifies and analyses the key decisions related on cooperation and operating conditions of transportation service platforms. The analysis is based both on the empirical case study of platform based living lab in Finland and literature review on cooperation strategies, living labs and technology platforms.

Keywords: Cooperative strategy, living lab, platform

1 Introduction

Well-functioning public transport is an essential part of pleasant and sustainable city life. More attractive and efficient public transportation is needed for tackling both environmental and transport infrastructure challenges of continually growing cities [2]. Technological advancement has enabled various means to improve usability and attractiveness of public transportation [10, 14, 15, 22, 19]. For instance, real-time sensor data can be collected from vehicles and utilized for providing more accurate and versatile travel information and for optimizing fleet capacity. The data can be also utilized in new digital services provided for the passengers, which opens new business opportunities and possibilities for improving the travel experiences of the passengers.

Living labs are open innovation platforms that often operate in specific contexts to allow co-creation, exploration and evaluation of concepts, services and related technological artefacts [1]. Living labs enable user-centered design of innovations in real life use situations, hence allowing iterative development of the concepts and artefacts [4]. Through involving end-users in real use contexts, the resulting artefacts will have ecological validity and higher chance of technology acceptance. Furthermore, various stakeholders – public and private, in addition to end-users – to cooperate in development and gain insights of the factors that lead to successful designs. In public transportation, buses and other vehicles are the focal points of the use context, surrounded by the whole transportation chain.

In this paper, we analyze the key decisions of the platform owners on cooperation strategies. We identify and analyze alternative strategies and their consequences on platform operating conditions. The analysis is based on the literature review on cooperation strategies, technology platforms and living labs. The results of the review are adopted for case analysis of platform based living lab, the Living Lab Bus (LLB).

The goal of the LLB platform (http://livinglabbus.fi/) is to facilitate technological development of transportation services in cooperation with companies, research organizations, public authorities and passengers. The research activities of the project aim to identify challenges and possible solutions for establishing open development environments (i.e., living labs). Moreover, the project aims to provide guidelines for implementation of service platforms and test environments based on the research and testing with real public transportation services [15]. The project and its development environment aim to fulfill needs and requirements of the project stakeholders (i.e., companies, passengers, service developers and public authorities) in three focus areas: 1. seamless multimodal travel chains, 2. travel experience, 3. technological solutions.

In this paper, we consider the main functions and capabilities of the LLB platform and related operating conditions. We analyze alternative cooperation strategies and market positions of the platform and the impacts of the cooperation and positioning on the operating conditions on the public transportation markets.

In the following section, we present the main capabilities of the Living Lab Bus development environment. In Section 3, we present conducted empirical research in the LLB environment and related research results and data on passenger satisfaction to illustrate the benefits of the LLB platform capabilities in research and development activities. In Section 4, we analyze different aspects of the cooperation and positioning of the LLB development environment. Finally, in Section 5, some conclusions are drawn.

2 The Main Capabilities of the LLB Platform

Goal of the Living Lab Bus environment is to enable the development, testing and demonstration of various services and technologies by using innovative electric buses as a concrete platform in a real use environment. The innovation environment is implemented in co-operation with private companies and research organizations together with the support of the public sector. In addition to those involved from the beginning, the objective is to open up the development environment for use of third parties.

The Platform can be used for collecting data, validating solutions and as an interface for involving end users in the innovation and feedback process, thereby supporting service and technology providers' business development, innovation, co-development and co-operation activities as well as product marketing. From the public sector point of view, the environment encourages and enables the development of solutions that support common goals such as user-centric services that increase the use of sustainable transport modes.

The LLB platform has four crucial capabilities which we have identified forming the basis for operating conditions and attractiveness of the platform for the cooperating organizations. These capabilities are: (1.) LLB as a test environment, (2.) LLB as a service platform for long-run service operation, (3.) LLB as a source of real-time data, (4.) LLB as a facilitator of improved visibility for digital services. In the following sections we describe these capabilities which are later illustrated with empirical data in Section 3 and evaluated in alternative cooperation strategies and related market conditions in Section 4.

2.1 The LLB as a Test Environment

The LLB is an open platform for technology and service providers enabling development, testing and demonstration of new technologies and services. It enables quick prototyping and testing for faster commercialization and credible verification with real public transportation services and real passengers, thereby ensuring user acceptance and providing customer references for technology and service developers.

2.2 The LLB as a Service Platform

The LLB is a service platform where cooperating organizations create new mobility service value chains. This cooperation enables also process innovations improving efficiency and reliability of service provisions, which increases attractiveness of the platform for service providers also in the long run, i.e., not only for short test periods.

2.3 The LLB as a Source of Real-Time Data

The LLB platform includes various censors installed in the buses enabling rich real-time data collection from the bus fleet. The censors are measuring several variables such as temperature, humidity, air pressure, CO2, location, acceleration, noise, velocity etc.

The platform collets also CAN data and other information about vehicle status. The real-time data is sent to the Living Lab Bus cloud and then provided for service developers with APIs. Moreover, local real-time data in buses can be utilized in the services and provided for the passengers with bus displays and mobile channels.

2.4 The LLB as a Facilitator of Improved Visibility for Digital Services

The buses involved in the LLB platform are equipped digital displays currently in the front of the buses and probably later in the other locations depending on the needs of the current and new service developers. The platform has also a landing page where the all involved services are collected and marketed for passengers using mobile devices in buses.

These channels improve visibility of digital services in the platform. Moreover, the LLB developer portal can be used to improve visibility of new services for other members of the ecosystem. In addition, services for transport professionals can be provided through the fleet management systems.

3 Empirical Research Illustrating the Capabilities of the Platform and Cooperation Possibilities

A crucial precondition for developing successfully new and innovative transportation services is a deep understanding of passenger needs. In order to achieve comprehensive and versatile knowledge on the current passenger needs and satisfaction, we conducted simultaneously a quantitative mobile survey and sensor measurements on the bus routes where the LLB platform was actively operating. In addition, immediately after the survey, we conducted qualitative study of bus passengers.

The empirical results can be utilized in the development of new services and also in the evaluation and testing of the existing services. Moreover, the implementation of the data collection demonstrates how the LLB platform can facilitate innovation activities of the participating companies. Next, we describe briefly both the quantitative (3.1) and qualitative (3.2) studies and related results, then we consider these results from the viewpoint of the operational conditions of living labs on the transportation markets.

3.1 Quantitative field research

The Helsinki field research was conducted in May 2017 in the bus line 23 (bus line operated by Helsingin Bussiliikenne (HelB)). It combined several research goals: a web-based survey directed to bus passengers, recruiting of volunteers for a longer follow-up probe study, collecting mobile sensor data using the TTY Rover bag and prioritizing field research in the HelB electric bus, which has sensors installed in the bus body.

The bus passenger survey was the central part of the field research and it was planned and conducted jointly by Aalto University and HSL. According to the sampling plan, the goal was to collect 300-500 survey responses, approximately half of those from electric bus passengers, and from different weekdays and times of day. The survey respondents were recruited by using flyers and total 2,500 flyers were printed. The field work started May 9th and was planned to finalized by May 21st. However, due to the slow progress, the work was continued until May 28th. Eventually, we got 356 responses, the response rate being 16.2%.

The survey form was based on the Webropol platform and the design was kept simple in order to keep the form accessible for different devices. The survey had three language versions: Finnish, Swedish and English, and the respondent was first directed to the language selection page. The flyer had a short description of the study in three languages and also an advertisement of the follow-up study in Finnish only. The flyer had both a short URL and a QR code redirecting to the language selection page. Each flyer had a unique 4-digit code (from 0001 to 2500) that the respondent was asked to fill in the survey form. HSL travel gift cards were reserved for survey respondents and the winners were drawn among those respondents that gave their email address.

The field work was done by HSL field researchers, who also carried the TTY Rover with them all the time. An initial field research plan, including work shifts, times and type of buses (diesel vs electric), was based on the electric bus timetable that was announced by the line 23 operator HelB. However, as the reliability of the electric bus timetable was still an issue, the actual operation of the buses had to be confirmed daily from the HelB operation manager. Thus, contrary to the initial plan, there are both electric and diesel bus observation on some days.

During their work shift, the field researchers got on the bus on one bus stop, handed out the flyers to the passengers and then got off the bus on another stop. The flyers were in sorted decks and the field researcher had to mark down the 4-digit code of the flyer on the top of the deck both before and after the journey. In that way, it was possible to know the codes of the flyers handed out during the journey, and the eventual survey responses could be connected to the specific bus and travelling time, no matter if responded instantly or only afterwards. The flyer codes and bus numbers were marked on an electronic log file that also saved the time and position of starting and stopping the journey. The field researchers also started the Rover before getting on the bus and stopped and saved that data after getting off the bus.

The sample statistics of the survey are depicted in Table 1. The survey focused on questions related to travel needs and satisfaction on the current bus trip. As the table shows answers based on travel experience with diesel bus or electric bus were both well represented. The both genders were also well represented as well as the all age groups between 18 and 80 years, even though share of older people was relatively small due to the digital survey methodology.

The respondents were asked to evaluate noise level, smoothness of driving and general travel experience on the scale from 1 to 5, where 1 was very unsatisfied and 5 was very satisfied. Figure 1 presents the frequencies of the passenger evaluations of the travel experiences in buses. The average value for travel experience was 4.01(std. deviation 0.713), which is relatively good as majority of the respondents gave at least value 3 for travel experience and only 9% of respondents were unsatisfied.

The trip purpose had impact on the satisfaction. The respondents traveling to work (average satisfaction 3.90) or traveling with child (average satisfaction 3.63) were less satisfied on travel experience, whereas the respondents traveling to schools (4.42) and to hobbies (4.25) were more satisfied on average.

Table 1 Descriptive sample statistics

Variables	Frequency	Freq. diesel bus	Freq. electric bus
Total sample size	356	200	153
Male	120		
Female	228		
		Mean	Median
Age		38	33
Income (€/ month before taxes)		2563	2450

Figure 2 presents passenger evaluations for smoothness of bus driving in diesel and electric buses. The average value in diesel buses was slightly lower (3.77) than in electric buses (3.85), but the difference was relatively small and not statistically significant, whereas the standard deviation of values was significantly higher in diesel buses (std. deviation in diesel buses 0.936 and in electric buses 0.728, sig. 0.001), which can be seen also in Figure 2, where the values for diesel buses are more widely distributed.

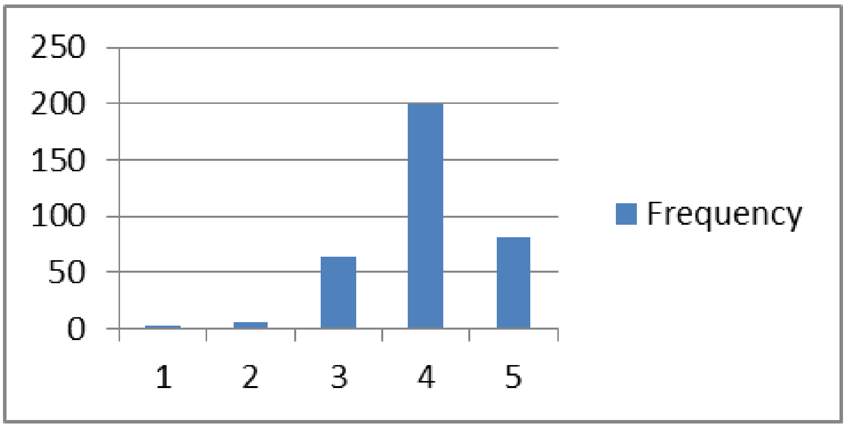

Figure 1 - Passenger evaluations of travel experiences in buses

(1 = very unsatisfied, 5 = very satisfied)

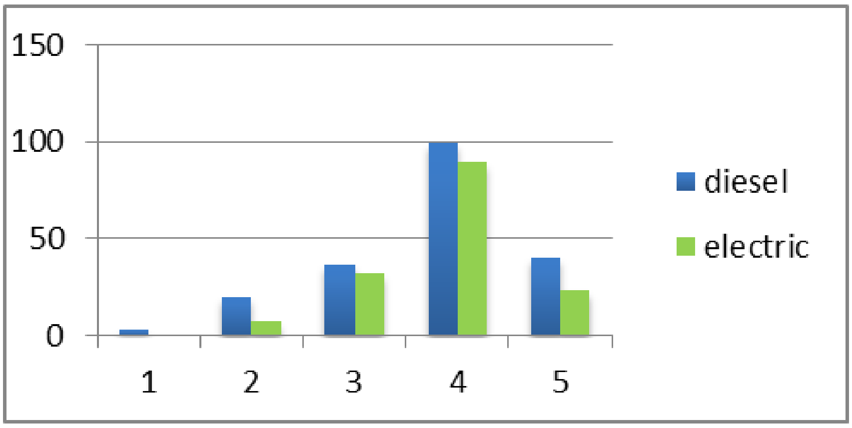

Figure 2 - Passenger evaluations of smoothness of driving

(1 = very uneven driving, 5 = very smooth driving).

3.2 Qualitative field research

As part of the Living Lab Bus project several qualitative studies have been conducted to collect insights on passengers' travel experience and the needs and expectations people have for future traveling services. Four different studies have been conducted in 2016-2017 to gain understanding of passengers' perspective on the short-distance, intra-city bus transportation. These studies included altogether 68 participants with varying backgrounds, all being regular bus users from two major cities in Finland, Helsinki region and Tampere. The studies consisted of preliminary interview study with ten students with international experiences [11], Idea generating workshops with 24 international students [12], In-depth ideation workshops with three different user groups [13], and a three-week Bus travel diary study with 20 passengers. These studies investigate elements of short distance bus travel experience, and the passengers' needs for potential traveling services from varying angles with different user groups.

The results show that passengers travel experience is a complex mix of both internal and external factors. These include passenger's own mood, needs and values; bus as a context, including social, physical, temporal and task contexts; and the transportation system, including bus lines, timetables, customer service channels. The long-term diary study provided us knowledge of the wide variety of passenger types utilizing the buses and their habits and needs related to bus travel and mobile device usage. The findings enabled us define specific elements that impact different peoples' travel experience the most. The co-design studies on the other hand, helped us also gain understanding of passenger's hopes and wishes for the future traveling services.

The findings of the qualitative studies can be utilized in varying forms in ideating novel digital services. Along the project, we have developed different tools and methods that communicate some of the main study findings in a concrete visual form. These tools are bus passenger personas, passenger journey map, and Context Cards [13]. The tools were created to transfer the knowledge gained by researchers further to the designers and software developers who are developing digital traveling services. The tools – bus passenger personas, passenger journey map, and Context Cards, are available at the Living Lab Bus Development Portal as a UX design support. Our aim is that these tools would be utilized by the software developers when designing new services, and with the help of our developed tools the services could be targeted to serve real passenger needs.

3.3 Impacts on Operating Conditions

The conducted empirical studies provided relevant information about passenger needs and satisfaction for the service developers and transport operators. The research activities were implemented in close cooperation with the local transport authority (Helsinki Region Transport) and the bus companies. This type of research would have been much more difficult to carry out without these research collaborators in the LLB platform. Thus, cooperation in the LLB platform with relevant participants is crucial for fast and efficient data collection and for related research and development activities. Moreover, these research activities implemented by credible research organizations provide reliable testing and verified references for service developers and vehicle manufacturers, e.g., comparison of vehicle types based on quantitative data and in-depth insights on customer needs and satisfaction from qualitative field research.

4 Market Structure of Public Transportation and Cooperative Strategies

As already observed, cooperation is a crucial element for operating conditions of living labs involving several stakeholders. This applies especially in the context of the public transportation services where public authorities and operators can provide easy access to tractable transportation data and passenger information. Moreover, subsidized public transport operators are often locally the only notable provider of public transport (or even local monopoly), making them very important partners for transportation living labs.

The cooperation can take various alternative forms, which have different impacts on operating conditions. A living lab environment enables the optimized use of organizational capabilities. In a living lab environment – that forms an experimental ecosystem – an organization can focus on the use and offering of their own superior resources and benefit from other living lab partners' superior resources over its own inferior resources [26] resulting in an efficient collaborative system. Ideally, the superior resources and capabilities of multiple organizations can be used to full extent to produce and deliver customer value.

Despite collaboration with others in the ecosystem, organizations can, however, maintain their independence as required in different business settings. The coopetitive mode of action [3, 9] enables companies to compete at the same time as they are collaborating with each other. Such situations may emerge, for instance, when customers emphasize the leading or coordinating role of a certain preferred company in a business arrangement. In such situations, the use of internal and inferior resources may take place in a legitimate way.

Mobile payment systems are an example of a complex multi-stakeholder digital business chain that requires several stakeholders with highly specialised capabilities to fulfil complete customer needs. Perhaps surprisingly, even commercial giants struggled in introducing successful mobile payment solutions solely by themselves. The Chinese Bestpay case [26] illustrates the challenges with self-organisational service innovation: the initial in-house development by China Telecom, the giant owner of the digital business/payment platform “Bestpay”, did not result in sustainable growing service. Company-internal development of flexible and superior resources in a changing business landscape appears more challenging than in a platform-supported open ecosystem.

In this section, we analyze the cooperation in living labs with public authorities, transport operators and other companies. The analysis is based on the observations from the LLB platform operating currently in Finland, but the analysis is also extended to other countries and generalized (to the appropriate extent) based on the related literature review of living labs, platforms, transportation services and cooperative strategies.

4.1 Public Authorities and Transport Operators

Public authorities and transport operators owned by public organizations (such as municipalities) have limited economic resources for providing public transportation services. In this sense, they are similar to private companies, but they usually have also politically defined social objectives such as reducing external costs of transportation[25], environmental sustainability and equal accessibility and mobility for the citizens [16, 17, 20]. Moreover, public authorities have authority and social reasons for regulation of transport [23, 24, 21].

According to Moore’s model on “Strategic Public Management triangle” [18] the public value impacts the legitimacy and support for the operational capacity of public services. Thus, social objectives should be identified and taken into account when planning cooperation with public authorities and operators. Thereby, mutual confidence can be strengthened, and conflicts with the other collaborators can be avoided in the living labs.

We analyzed relationship between the common social objectives and the LLB platforms capabilities. The capacity and resources of the LLB platform for providing testing activities (1. capability) is limited. Similarly, the platforms capacity for providing improved visibility (4. capability) for new digital services (e.g., through the landing page and digital bus displays) is limited. The optimal allocation of these limited resources is usually somewhat different between profit maximizing companies and public authorities optimizing the social objectives within economic constraints. For instance, public authorities would provide more testing possibilities and visibility in the living lab for new services which foster also their social objectives in addition to the business objectives. For example, feeder service to the bus stop organized by shared taxi service would be preferred over private taxi based on sustainability objectives. Therefore, the objectives of the platform owners and key partners need to be clearly defined, and possible conflicting objectives with new partners must be identified and solved in contracts and cooperation management practices.

The other distinction in objectives between public transport operators and organizations developing new technologies and services is that public transport operators target market is the local transport market whereas technology and service developers are typically targeting for global markets with customer references obtained from the local market. These distinctions are not necessarily contradictory, but require cooperation for reconciliation of distinctive objectives. Moreover, the platform and related rules of cooperation should be designed so that requirements of the local transport market can be taken into account and adapted when the platform is extended for new markets abroad.

4.2 Cooperation Between Companies in the Platform

The founders and owners of the platform define the main objectives, capabilities, rules and directions of further development of the platform. Thus, understanding the motives of the platform owners is a key for further analysis of the platform and related cooperation and operating conditions [5, 6, 7]. Gaver and Cusumano [8] present four effective practices for platform leaders based on several case studies of leading technology companies.

The first proposed practice is to develop a vision of how technology (or service) could become an essential part of a business ecosystem by designing an element with platform potential (essential function with easy connection for others) and by identifying third-party firms as potential complementors for the platform. In the LLB platform the capability to collect and deliver versatile real-time data (3. capability in Section 2) from the fleet of buses can be seen as an essential function with easy connection for service developers and other data users. In the LLB platform this capability is essential for the organizations already involved in the founding phase, i.e., research organizations, transport operator, bus manufacturer and technology and service providers. The vision is that the platform attracts more service developers for utilizing this currently unique combination of capabilities.

The second proposed practice is to build a rich technical architecture and connectors by adopting a modular architecture with interfaces enabling to build services on the platform and by sharing intellectual property of connectors to reduce costs of connection and facilitate complementary innovation. In the LLB platform the interfaces to the real-time data and other collected data are provided in the LLB developer portal, which provide also documentation of the interfaces for the data and guidelines and tools for service developers to advance innovation activities.

The third proposed practice is to build a coalition around the platform for co-creating a vibrant ecosystem by articulating a set of mutually enhancing business models for different actors, and by sharing risks with complementors, and by working for reputation as a neutral industry broker and working for developing a collective identity for ecosystem members. In the LLB platform the work for building ecosystem has started and already participating national research organizations, cities and public transport operators form a good neutral base for the ecosystem, which have incentives for cooperation with different actors in the transportation markets.

The fourth proposed practice is to evolve the platform while maintaining a central position by keeping innovating on the core for ensuring that it continues to provide essential function to the overall system, and by making long-term investments in industry coordination activities. In the LLB platform the four capabilities can be seen as enablers for essential functions of the platform. Thus, continuing innovation is needed to keep these capabilities attractive. For instance, data collection in the buses should provide as versatile and rich data as the latest censor technologies enable. Respectively, new display technologies should be tested and applied for ensuring improved visibility for new services in the platform.

Table 2 summarizes the critical capabilities needed in collaboration in the LLB platform from the key stakeholders. On each row is described what certain stakeholder needs (i.e., on the first row are described needs of public transport operator) from the other stakeholders (i.e., columns) especially when operating with the LLB platform.

Table 2 Critical Capabilities and Factors Needed in Cooperation

	Public transport operator	**Bus manufacturers**	**Technology and service providers**	**Digital platform provider**	**Research organizations**
Public transport operator		-Collaboration for bus testing -Responses to passenger feedback	-Collaboration for utilizing platform capabilities to support social objectives of PT operator	-Compliance of policies for content and services displayed -real-time data for transport operations and management	-Research collaboration for supporting public transport development
Bus manufacturers	-Access to passenger feedback		-Value adding complementary technologies and services for vehicles	-Testing capabilities	-Collaboration for R&D
Technology and service providers	-Access to passengers as customers	-Physical premises for devices		-Capabilities for testing, visibility, data utilization in service provision	-Collaboration for R&D
Digital platform provider	-Operating bus fleet as physical base for digital platform	-Physical premises for hardware and censors			-Collaboration for platform R&D
Research organizations	-Access to passengers as research objects -Collaboration in data collection	-Insights on information and knowledge needs for research planning	-Insights on information and knowledge needs for research planning	-Capabilities for versatile data collection and innovative research experiments	

5 Conclusion

In this paper, we have analysed cooperation strategies and operating conditions of platform based living labs in the case study of the Living Lab Bus platform and with related literature. We illustrated potential benefits of cooperation in the LLB platform with empirical studies providing knowledge on passengers' needs from different perspectives and passenger evaluations of electric and diesel buses. These studies can be also complemented with the censor data in the LLB platform. We identified and described the key capabilities of the LLB platform, which we analysed with the proposed best practices for platform leaders.

The Living Lab Bus provides an initial digital ecosystem and platform for different types of actors to participate in a hands-on manner. The combination of public and private sectors as well as the inclusion of research and business actors facilitates a broad mixture of conceptual and technical experiments for intelligent transportation. A single actor, even a large one, would not have fluent access, resources, and capabilities to all parts of the public transport service delivery chain ranging from hardware installations in real buses, real-time cloud APIs, and payment gateways to feedback studies on end-user experience. All these are part of the current LLB ecosystem. Future work on the fluent operation of LLB, the living lab, an open innovation platform for public transportation, will address appropriate structuring of administration and rules of operation.

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