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Developing Innovative Live Video-to-Video Communications for Smarter European Cities

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Abstract. The LiveCity Project effort intends to create a city-based "Living Lab" and associated ecosystem to pilot live interactive high-definition video-to-video (v2v) on ultrafast wireless and wireline Internet infrastructure for the support of appropriate public service use cases among a number of city user communities initially in four major European cities (Dublin, Athens, Luxembourg (city) and Valladolid). The essential aim is to empower the citizens of a city to interact with each other in a more productive, efficient and socially useful way by using v2v over the Internet, as the latter can be considered to improve city administration, reduce fuel costs and carbon footprint, enhance education, improve city experiences for tourists/cultural consumers and save patients' lives. LiveCity underpins technology which has the ability to massively scale while it integrates the necessary ingredients in an efficient low-cost manner and provides a proper testing ground for a mass market deployment to the cities in Europe.

Keywords: Future Internet (FI), interactive communication, interoperability, Living Lab, QoS, right of way, video-to-video (v2v).

1 Introduction: Developing Living Labs in Modern Cities

The Digital Agenda for Europe [1] intends to sustain fast and ultrafast Internet access as well as the development and operation of several "*open platforms*" able to provide new and innovative products as well as a variety of related services, especially focused upon the framework of the *Future Internet* (FI) ([2], [3]). Under the present context, and particularly in urban environments, both citizens and "legal entities" (i.e.,

organizations, enterprises-companies, (state) authorities, etc.) are actually facing with a multiplicity of challenges where appropriate investments -or properly selective policy initiatives- in pioneering ICT-based solutions can help "*to address and to promote innovative responses*", especially those based on user-driven initiatives [4]. Of particular importance become various activities ([5], [6]) aiming to develop modern solutions or facilities/services of higher quality in communications that should make a beneficial and effective use of the wider context of the *Internet of the Future* [7].

Until today, user-driven open innovation methodologies have proven that they can drastically improve the efficiency of the innovation process by bridging between R&D and market entry supporting better and faster take-up of R&D results [8]. In this scope, they are very rapidly becoming the new mainstream method of innovating. Living Labs are specific examples of such open innovation environments in real-life settings, in which user-driven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures. Cities (or urban areas) are continuously faced with major challenges that require investment in innovative solutions (particularly the ICT-based ones) to improve the quality and efficiency of their infrastructures and services offered. Some anticipate and are "leaders" in adopting smarter development models and may perform a kind of pioneering role in engaging the user in the expected innovation process. Building upon existing user-driven innovation initiatives in Europe, the critical aim is to ensure a wider implementation of open platforms for the provision of Internet-enabled services in cities [9], [10] and thus to include an active involvement of citizens. These platforms should be able to develop "innovation ecosystems" accelerating the move towards "smart" cities" and providing a wide range of opportunities for new, higher quality, and sustainable services for citizens and businesses as well. In fact, this also delimits the essential framework that is actually taken into account by the ***LiveCity*** *("Live Video-to-Video Supporting Interactive City Infrastructure")* ***PSP-ICT Project (Grant Agreement No.297291)*** effort, aiming *-among other issues-* to the development and the operation of suitable applied initiatives (through selective pilot actions) with the target of accelerating the uptake of innovative video-to-video (v2v) Internet-based technologies and services in cities. These pilot actions will apply user-driven open innovation methodologies across "networks" of smart cities and may combine: (i) User-driven open innovation; (ii) Connected smart cities, and; (iii) A variety of related Internet-based services to be further examined, tested and deployed. In this scope, it should be a matter of particular importance for the entire LiveCity context to "identify" channels and/or other means for potential interaction with related innovative and extended ecosystems, such as other existing *Living Labs*[1], intending to "bridge" the gap between the development of Internet-based technologies and their rapid uptake in new services that can significantly affect users communications'

[1] For the context of our approach, a "Living Lab" is considered as: An open innovation environment in which user-driven innovation is supported by the availability of established, consolidated services and ICT infrastructure for creating, prototyping and using new products and services in real-life environments. There are actually various Living Labs in different domains, spanning from eHealth to energy optimisation, efficiency and from intelligent mobility to inclusion of the elderly and disadvantaged people.

profiles ([11], [12]). Within the wider strategic scope for growth [13], Digital Agenda Europe looks to the future for Europe and recommends that, as a consequence of global competition and demographic ageing, citizens of Europe will have to at least work harder, longer - and with the help of ICT - work smarter in order to increase standards of living [14]. The agenda charts a course to maximize social and economic potential by employing ICT for doing business, working, playing communicating and especially for expressing ourselves freely with the Internet as a "key ingredient" [15]. In particular, in the context of the Digital Agenda the Policy Support Programme (PSP), *Objective 5.1* seeks pilot projects for open innovation of Internet-enabled service in smart cities. It is within this detailed and quite focused scope where the *LiveCity Project* proposes one significant forthcoming Internet-based service, that is video-to-video, and apply it in a number of applications with diverse user communities in different European cities in order to validate the ingredients which comprise the service, evaluate the stakeholder experience and prepare for a mass market deployment, also implying a multiplicity of explicitly identified benefits-advantages for all involved actors.

2 The Innovative Context of the LiveCity Effort

In the past decade a variety of video-based communications [16] has entered the market place, to become ordinary in several domains including our working environment, our homes and applications on mobile devices ([17], [18], [19]). However we are still gagging behind from the goal of video calls being as easy and ubiquitous as phone calls are today – across any network and between numerous devices. There are a number of existing gaps on the pathway to the realization of the Future Internet with live v2v. These gaps appear at a number of different levels: (i) From an end-user point of view, there are gaps in understanding what video-to-video really is. As a consequence, there are gaps in terms of understanding "how the end-user can exploit the video-to-video" in order to obtain societal or economic benefit and in which -by priority- specific domains; (ii) From a service provider network infrastructure point of view, there are gaps at the level of: how to effectively deliver a Future Internet experience with v2v; what tools and protocols are required in the (existing) network infrastructure, and; how do the previous "relate" to the application, in order to deliver truly globally reachable applications [20] with adequate quality support; (iii) From an infrastructure design point of view, there are also gaps in terms of interoperability of the heterogeneous networks; the manner how infrastructure(s) can interoperate, seamlessly and globally to deliver a quality experience becomes a critical issue and affects investments and development [21]; (iv) From a service delivery platform point of view, there is a gap in terms of having heterogeneous network substrate in which to test new services; (v) From an applications provider point of view, the issue is "how to obtain access" to the power of the Future Internet where it is truly globally reachable [22]; (vi) From an end-point device consideration, there are gaps mainly in terms of the device(s) interoperability. The LiveCity effort aims to fill the above gaps, by providing appropriate responses, per separate option. It is somehow important to clarify that the project is not addressing video

coding/transcoding or other data coding issues, but it mainly deals with connectivity issues and global reachability at the IP layer (OSI (Open Systems Interconnection) Layer 3) [23]. The LiveCity project is not addressing video application encoding/ transcoding issues (i.e., the OSI Layer 7). To this aim, LiveCity project considers standard video encoding already available in off-the-shelf devices. In order to adequately "cover" the expected targets, LiveCity will seek to resolve a variety of issues relevant to the following matters: (i) Intercarrier interoperability; (ii) v2v service interoperability between different carriers; (iii) Compatibility with most used laptops, notebooks, smart-phones & tablets; (iv) promotion of the "First-for-consumers" option, that is by supporting simplicity of installation and usage; (iv) Seamless operation between end-point devices and corresponding applications; (v) Right of Way (RoW) to be provided over various network types; (vi) Consideration of a large number of contacts addressable, together with globally reachable solutions; (vii) Integration of video application within vertical applications; (viii) Extension of FI ecosystem [24] to include mass market in eHealth, Education, Enterprise, "Live Cities" and other types of communities, and; (ix) Industry clarity on the logical technical architecture of the FI [25].

2.1 Technical Approach

LiveCity uses forth generation (4G) wireless technology (LTE and WiMAX) coupled with 3.5G wireless technology -where 4G is not available- and also uses fixed line xDSL broadband technology where fixed line is more appropriate than wireless, thus creating a network of cities and including a Right of Way without interference from unwanted traffic [26] so that each user in any of the involved cities can experience live interactive HD video-to-video. Therefore, LiveCity becomes a technology integration trial which aims to offer advanced services to over 3,000 users in the involved European cities. The project brings together an ecosystem of partners, technologies and subject matter experts to support public service use cases. Thus, it creates a user-centered networked Living-Lab initially of four cities (i.e., Dublin, Athens, Luxembourg and Valladolid) within a public-private-people (PPP) partnership (as shown in Fig.1). This Living Lab provides a systematic user co-creation approach integrating technology to deliver new innovative processes that are integrated through the exploration, experimentation and evaluation of innovative ideas, scenarios, concepts and related technological artefacts, in real life use cases. The LiveCity approach allows all involved stakeholders to concurrently consider both the global performance of the v2v service and its potential adoption by users. In fact, it creates a cross-border network of smart cities while its smartness comes from the ability to be interactive and live between remote locations between any citizen being in any appropriately connected city. LiveCity public service use cases are driven by public service operators. The technology and network partners come together to leverage existing (xDSL, HSPA) and emerging network infrastructure (LTE, WiMAX) combined with emerging off-the-shelf Virtual Path Slice (VPS) control software platforms and video-to-video applications software components, together with display/camera devices. This unifying approach underpins an exploitable

platform which can later be rolled out to other cities and communities as well, on a mass market basis.

LiveCity underpins technology which has the ability to massively scale - the barriers to video calling have come down with ubiquitous high bandwidth Internet access [27] and lower cost of cameras and high-definition display devices. The project integrates all the necessary ingredients in an efficient low-cost manner and provides a testing ground for a mass market deployment to cities in Europe. In addition, it brings together diverse working groups who can derive social and economic benefit from the live high-definition (HD) interactive v2v service. LiveCity exploits the concentration effect of these user groups to show that a homogenized service is available on a mass market basis, over heterogeneous network infrastructure [28]. The current public Internet provides today a globally reachable "best effort" network. It is envisaged that the FI of tomorrow includes a Right of Way for a user's traffic without interference from unwanted traffic. Such RoWs are already implemented in virtual private networks by using various quality of service (QoS) mechanisms [29]; however, a right of way without interference from unwanted traffic is not available to the broad spectrum of users in the mass European market. In order to provide maximum utility for all potential users, this right of way needs to be globally reachable and supported on all *-or on most-* Internet environments and at low *-or at least at affordable-* cost.

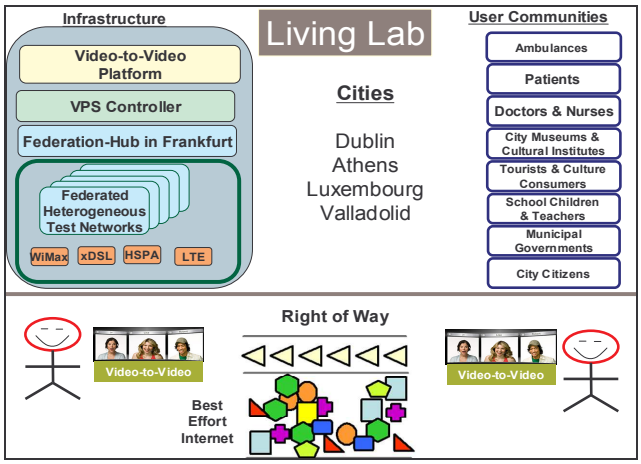

Fig.1. LiveCity Living-Lab infrastructure to support user communities

Today's Internet provides strong support for elastic traffic. However, inelastic traffic sources such as high definition video-to-video are not well supported on the current Internet. It would be unacceptable for the live HD images to be buffered and visible to the user, later. Consequently, live video applications require a Right of Way without interference from unwanted traffic in order that the inelastic traffic can get to the user and support the live experience, in a wide variety of applications covering business and/or educational-entertainment aspects [30]. Within this identified market- and technology-related "state" which really implicates the necessity for the promotion and the development of innovative methods and ways of communication, by using

existing e-communications facilities, LiveCity's vision is to conduct video-to-video pilots for a range of user communities initially in four European cities for a range of diverse applications and to support the network infrastructure with a proper RoW. By using a common network infrastructure platform for building this kind of RoW in the target cities, costs can be significantly reduced and interoperability can be further enhanced. For example, if each city network operator used a different technology approach to building the RoW, then barriers to use would be high, reachability would be confined to a given network footprint, take-up would be low and costs would be still high. On the contrary, by seeking a common interoperable standard, costs can be low, reachable and related solution(s) can be widely adopted even in the near future.

3 Developing Appropriate Scenarios of Societal-Economic Impact

The essential aim of LiveCity Project effort is to empower the citizens of a city to interact with each other in a more productive, efficient and socially useful way, by using high quality video-to-video over the Internet. Video-to-video can be used for an immense diversity of potential applications such as for saving patients lives, for improving city administration, for reducing fuel costs, for reducing carbon footprint, for enhancing education and for improving city experiences for tourists and cultural consumers - just to mention a few. We can imagine a world where live HD interactive video-to-video is as easily available on any display device on any city street as the air we breathe; a world where a video call with HD quality is as globally reachable to any city as a plain old telephony call; a world where, *remotely*, communications can be realized between numerous users in any city, live and in high definition, instantaneously; a world where any video screen coupled with a video camera in any city can connect a high definition full screen video call at an attractive cost with seamless, utterly simple usability [31]. This is in fact the estimated world of LiveCity! In particular, the intended priority is to be deployed around the structuring of several essential and well-defined scenarios and/or use-cases, as below, per separate case:

Municipal Services: Using video-to-video for public administration and public information services will radically improve the access to and range of services available by the Internet; it will also illustrate to the wider community the potential benefits of face-to-face communication for specific services which is expected to result in a better user-service provider relationship, therefore improving trust and the uptake of new services as opposed to voice only or web-based services; it will also decrease fuel costs and green house emissions by reducing travel and traffic within the city. In addition, video-to-video will enhance efficiency and utility of the offered services and will improve the accessibility and the comfort in use of e-government services and physical service to the less ICT savvy, disabled and elderly citizens. As evident, the above aspects implicate for numerous social and economic impacts, thus resulting in a number of concrete benefits for individuals. *(Effort for that purpose is to be deployed in the city of Valladolid, in Spain).*

City Education: As ICT becomes more and more prevalent within schools, a related pilot action would be about developing a scenario where a video-to-video network is established between city schools to enhance education and to support real interactivity. This will permit schools to collaborate on projects, therefore allowing for the sharing of resources and teachers. This also implicates for several major societal benefits such as: Ability for leading teachers to provide classes to students across the globe; provision of teachers' training facilities between schools and training centers; improved cultural exchanges between schools from across Europe, thus increasing awareness of arts, science and social issues; increase of parental involvement in education through the provision of teacher-parent training, therefore lowering the gap of knowledge between parents and their children; ability to create richer educational experiences using interactive v2v that will improve pupil attainment; contribute towards improving the learning experience of pupils, as early identification of educational scenarios will allow for development post-project of education services; better transfer of skills offered between pupils and teachers from different schools, in a cost-efficient way; facilitating EU-level and national political ambitions to improve education standards and, *eventually*, support for the creation of an EU-wide universal education system, accessible by all sections of society and supporting gain of knowledge through access to expert teachers, and; contribution to the generation of new knowledge, new ideas for learning and teaching through the use of video archives. (*Work to fulfill these expectations will be in Dublin and in Athens).*

City Experiences: In order to enhance tourism, cultural and city marketing information, a proposed pilot action aims to consider the usage of v2v between museums and/or involved cultural institutes. Local city administrations can also be involved in choosing the figure and further promoting it. This can extend the ability of the involved legal entities across Europe to provide new shared (and occasionally mobile) experiences for visitors and for potential virtual visitors. The corresponding LiveCity-based use case can so improve the interactive and social nature of museum (and/or other cultural institute) exhibits and can potentially attract more visitors who will remain connected for longer periods of time. Through the use of appropriate devices it will be possible to "extend" the cultural experience in order to cover a wider part of the involved city, therefore opening up the possibility for creating exhibits with "mixed" content (that is from the museum entity with real-world originating content). Application will also be beneficial for the participating museums/institutes to create shared, multi-user experiences that will include visitors both on- and off-site; this can lead to "co-operation and sharing of content" between geographically diverse locations with medium- to long-term financial benefits. The proposed initiatives will support development of tourism within cities as well as in a wider European context; in fact, tourism will benefit from leveraging the power of the Internet with the personal touch required for customised holiday solutions by visitors from remote locations. This can improve the visits and profitability of tourist locations and will act as "a method of driving new revenue streams". *(The related pilot initiative will be deployed between Athens and the city of Luxembourg).*

City Emergency: The proposed use case concerns a city hospital emergency department team who has reduced effectiveness because they cannot "see" and

optimally treat the patient remotely during the *"*golden hour*"* before the patient gets to hospital in the ambulance. The corresponding pilot activity will experiment with live high-quality v2v between ambulance and hospital and study how to enhance patient outcomes (e.g., shorter time to administer thrombolysis clot busting drugs in the case of a stroke or survival in a case of a polytrauma) and so to have early availability of expert opinion at the scene, when necessary, This should implicate speedier access to senior decision making and optimal referring to appropriate centre to facilitate further management. The use case will be initially simulated and is expected to be later implemented in a live clinical setting. *(To this aim, work will be performed in the city Dublin, in cooperation with the University of Greifswald, in Germany).*

City eHealth: This is related to a patient who needs monitoring and/or treatment for pre- and post-surgical control, relevant to medical cases. The use of v2v between the home of a patient and hospital/clinic support group will enable medical personnel to deliver enhanced patient support at lower cost and higher utility. By being able to provide faster and more reliable video feeds and medical telemetry tests (tele-diagnosis and tele-monitoring), LiveCity can facilitate and improve: the quality of the health service as more often than usual contacts may apply; quality of life, and; ambient living conditions for the involved patients. The inclusion of v2v can provide better solutions to the health problems and can result in fewer complications and lower medical costs, together with a reduction of travels and traffic. The pilot will use v2v between patients and medical centre(s) in order to support safe tele-monitoring activities. *(The relevant pilot initiative will be deployed in Athens and Dublin).*

All previous thematic sectors are quite representative among those shaping the wider profile of citizen's inclusion in a "smart city" where the use of Internet-based facilities may be the "tool" for realizing further transformative actions towards a more digital-based activity and economy [32]. Thus, *"LiveCity"* covers a diverse of services-applications, while really "embracing" a wide number of users by offering them the opportunity to select among various activities and according to their specific needs and/or priorities. As the proposed actions are to be implemented via the collaborative effort of city authorities and (public) service operators, the expected outcome may be important and immediately applicable and beneficial in real life. This can also further strengthen the role of the "user-citizen" in the innovation lifecycle, while facilitating both technological and social innovation. Stakeholder evaluation and key performance indicators will also be measured, analyzed and disseminated, *appropriately*. The essential hypothesis is that these indicators -once properly identified- can then be significantly enhanced with the usage of video-to-video communication. (For example, in the emergency services use case important indicators are time to delivery of clot busting drugs and patient survival rate). Other indicators will be collected/evaluated for the different pilots and a feasible business case for the rollout of services to major European cities is also to be considered.

4 Synopsis

The proposed LiveCity-based solutions are expected to be an *"active and indispensable part"* of the local cities ecosystems, thus being able to support contributions for the effective improvement of the living standards. In parallel, work also intends to support development of interoperable *-through the selective cities-* actions for testing and validation of the proposed services-applications, with the aim of a broader European dispersion and for the benefit of a wider set of potential recipients, with the target of *"bridging the gap between the development of Internet-based technologies and their rapid uptake in new services"* in real and fully applicable scenarios. To this, it should also be expected that the end-user will be an active "participant" and simultaneously a sincere "evaluator" of the proposed solution(s); this last requirement has been very carefully taken into account in the context of the complete *"LiveCity"* effort where end-users' feedback is expected to be a critical part of the entire implementation and development process. Among the essential core expectations and benefits of the whole project are: (i) The creation of a city-based Living Lab and associated ecosystem to pilot live interactive high-definition v2v on ultrafast wireless and wireline Internet infrastructure for the support of public service use cases among a number of city user communities in some selected European cities; (ii) The implementation of public service use cases with over 3,000 users, by focusing on the application of v2v in a number of themes (e.g., Municipal Services, City Experience, Education, Emergency and eHealth) with a remarkable validity for the citizen, so that to enhance a range of key performance indicators. (iii) The realization of piloting video-to-video services by: conducting user-centric evaluation experiments; collecting key performance indicators from embedded users; evaluating services in conjunction with key-stakeholders and public service operators; disseminating results to public service network operators and city authorities in Europe; (iv) The acceleration of live interactive HD v2v mass market take-up across cities in Europe, by showcasing successful use cases, producing "how-to guides" and providing a "get up and go" solution to public service operators.

A critical success factor should be the appropriate combination of innovative *-but adequately mature-* technologies that are to be offered by the involved network operators. The fact that already existing platforms and/or related facilities are to be considered as the essential "background" for development may by the pure guarantee that *LiveCity* should really emphasize on real and applicable solutions instead of proposing others that necessitate additional investment of resources and extra budget. Thus, through the implementation of the LiveCity pilots, suitable measures are to be taken for adapting, integrating -or extending- existing open platforms/environments in cities for stimulating the development and the validation in real setting(s) of innovative Internet-based platforms and services [33]. LiveCity proposes a quite "balanced" partnership scheme including "actors" from several areas (i.e.: industry and business sector, citizens, public authorities and academia); this is done in order to efficiently realize solutions-facilities that compromise appropriate considerations as well as to exploit potential "synergies" (such as addressing legal, governance and platform interoperability aspects), to promote and forward the European concepts (and/or approaches) in an international context, and to broadly share and disseminate multiple experiences. Expected results/findings should be particularly important for

further market development and for the support of local economies (e.g., via the development, validation and integration of new ideas and concepts) and they can also contribute to the offering of new services and products with positive effects to wider economy-related sectors.

In conclusion, LiveCity project intends to achieve a number of infrastructure- and application-specific social, technical and economic impacts. The identified impacts reflect both longer-term results which will benefit society and the scientific community over the long-term, and impacts which will be relevant in shorter- to medium-term application scenarios. Consequently, the project supports development of new business models in service provision, hardware development and for software developers, while it improves interoperability between networks and v2v providers. It also enhances security, privacy and trust issues through exploring the social and ethical aspects of v2v. In addition, it embeds development of test cases in real world scenarios which will specifically enhance digital literacy, skills and inclusion, while it insists on the development of scenarios to address societal issues that are among the actual high-priorities of the European strategic policy framework.

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