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ENHANCING PLACES THROUGH TECHNOLOGY

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with a Foreword by Alessandro Aurigi

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FOREWORD

Space is not a platform – foregrounding place in smart urban design

Alessandro Aurigi

INTRODUCTION: AUGMENTING OR DENYING SPACE?

The Brazilian city of Curitiba, capital of the Southern state of Parana, is well-known globally for a series of interesting planning initiatives and choices promoted through its recent history by some of its administrators, amongst which probably the most prominent has been the architect-planner Jaime Lerner. One of the most notable pieces of innovation in the city, enjoying a global resonance, was the original design of the mass transport system known as Bus Rapid Transit (BRT). Thanks to various ideas, mainly related to the 'tube' design of the bus stops and the consequent affordance of a very fast exchange of alighting and boarding passengers, the operations of the BRT's long buses could be almost as efficient as that of an underground system. The story of the design and evolution of the BRT presents an interesting – albeit indirect – point of reflection for those involved in efforts of 'smartening up' the city through the application of technology. Lerner often tells the story of bus drivers solving through an extremely simple and low-tech idea – the application of two small marks on the bus's window and the stop's structure to allow drivers to always stop at exactly the same position – a problem that otherwise would have called for complex and expensive hi-tech solutions [1]. Similarly, when the BRT system was augmented with a new 'express' type of bus that would not call at all stops, allowing for quicker longer-haul transfers within the city, the issue of allowing such buses not to be blocked by slower vehicles stationing at facing stops in narrow roads arose. Again, this could have easily called for all sorts of smart, digital 'solutions', such as geo-locating the vehicles, sensing their presence and mutual position, maybe automatically controlling their speed through actuators in their engines linked with the centrally managed system. What was done, however, was rather smart indeed, yet involving no high technology. Simply, opposed stops were moved slightly, so that they would be staggered and allow enough space for the express buses to go through even when two slower vehicles were loading passengers at both sides of the road. This points at two key hints that matter in smart – in its wider sense – space design. One is of course the importance of simplicity. The other one, however, is the often underplayed – if not entirely forgotten in contemporary digitally-driven urban visions – importance of physical space and the role and agency it has in the city.

To state that 'the role and importance of physical space is not to be overlooked in smart city design' might sound terribly obvious and not worthy of discussion, but when it comes

to conceiving digitally augmented places, the proverbial danger of focusing on the finger pointing at the moon rather than admiring the moon itself can be a very real issue. In circles of smart city scholars and practitioners it is way too easy to concentrate on everything digital whilst overlooking or branding as outdated what we already know about the city. This way, we can end up associating change, solutions and agency to the former whilst looking at space as simply the recipient of technological innovation, or the stage where new technologically induced lifestyles will unfold.

The history of the intersection of urban space and digital technology shows how this has been driven by deterministic, tech-first (or even tech-only) perspectives in which cyberspace was the change factor making the difference, whilst people and physical space were at the receiving end of it. When the emergence of advanced telecommunications and virtual spaces were celebrated in the late 1980s and early 1990s debates were dominated by hyperbolic views of digital technology improving an otherwise decaying and disempowered world by making it more environmentally sustainable (see for instance [2]); boosting new forms of human association [3]; pointing at new ways of settling (or re-settling) in economically and socially viable small towns whilst cities became obsolete [4]; and generally affirming new, revolutionary economic and production models [5].

Linear, simplistic views of an all-dominating technology have been met of course with lively reflections and critique from various disciplinary perspectives. Yet, prevalent responses and continuous challenges to technological determinism have mainly engaged the socio-economic and political side of urban management and development, leaving physical space in the background. Social constructivist approaches, as well as those looking at public participation and lack of social inclusion and justice have looked at the social dimension of augmented place-making, yet often take for granted physical space as something already there, that did not need to be seen as a particularly active part of the equation. From early discourses of digital divides, inclusion and participation ([6], for instance) to more recent debates on smart citizenship ([7], [8]) and community participation, to yet further critique engaged with issues of socio-economic development, equality and justice ([9], [10], [11]), the role of physical space and its potential agency through design and ability to affect relationships could have deserved more attention. This absence – or quasi absence – is more pervasive than one could expect, with the physical aspects of place and spatial design being framed – from a variety of perspectives – as belonging to some fairly static – if not entirely problematic – background in the smart city narrative.

SPACE AS A GENERATOR OF PROBLEMS

First of all, the widely deterministic discourse coming from the corporate ICT sector [12] and smart city entrepreneurialism needs – in order to assert the urgent need for its proposed solutions and allegedly new urban models – to declare the current city as terminally ill. Smart city hype from a wide variety of actors tends to leverage on very much the same discourses of over-urbanisation, critical densities and the consequent pressures on urban

resources, the environment, citizen safety and management practices. Traditional ways of framing, understanding, managing and designing cities are branded as inadequate and fundamentally hopeless without the redeeming influence of high tech systems [13]. This is a revival and commercial leveraging of the utopian hyperbole of the start of the 1990s. The brand new world of cyberspace, seen twenty years ago as replacing many decaying aspects of urbanity, is now expected to save an equally critically malfunctioning city, and this is proposed through a series of very real hardware and software products and systems. In the perspective of mainstream smart city promotion, the various limits and issues related to physical space end up therefore being exaggerated and functional – hence looked at and highlighted – to the urgent digital innovation push. At the same time ways in which space could also matter, both in the sense of what it offers and of what it could contribute to change, are either entirely overlooked – as in the Cisco, IBM or PlanIT literature – or presented in an equally radical way, through the logic of producing brand new smart towns and settlements.

SPACE AS A FIELD OF ANALYSIS

A much more research-based and deeper-looking approach, yet somehow cognate to framings of the city as problematic and in need of brand new interpretative perspectives, is the growing – or somehow long-existing and now revitalised – field of studies related to spatial analysis and what has been defined as the 'new science of cities' ([14], [15]). Civic space and places constitute a field to be researched and analysed. Obviously, and in many ways, they have always been and rightly so. But the growing ability to harvest 'big' data through both civic installation of sensing hardware, and user/app-generated information about many measurable aspects of urban functioning – from environmental conditions, to vehicular and pedestrian movement and people's behaviour in public spaces, has opened up new and exciting horizons for spatial analysis. What used to be fairly static analytical tools based on Census-fed GIS systems can now develop into real-time, rich and sophisticated instruments. Whilst there is nothing wrong with this *per se* – in fact we need to be able to triangulate as much evidence as possible to reach a better understanding of the dynamic urban environment – the city, and above all its physical places and their design, act here as an information provider and a field to be studied. On the one hand difficulties remain in actually effectively triangulating very different forms of evidence. What happens to phenomena and aspects of the city that are not easily measurable, for instance? On the other hand, physical space is interesting as the object of analysis, but much less engaged in terms of its design and ability to change things. And indeed many aspects of actual space design are not as easily coded into such 'spatial' analysis, where human movement and behaviour (so, social aspects of urbanity) and their environmental consequences have the lion's share of the attention.

SPACE AS STAGE OR PLATFORM

Much work – both in terms of critique and practice – has gone into considering how the development of digitally-enhanced places and of situated interactivity could be re-framed in ways that would make it more locally engaged, participatory or based on provocative and alternative concepts to mainstream e-governmental, city management and place-marketing approaches.

This work ranges widely. One aspect is the reflection on the non-neutral, contested nature of urban analysis systems and dashboards [16] and the critical analysis and facilitation of various forms of grassroots or public-private action involving the production of locally relevant smart initiatives and the networking of these [17]. Another is the conception of non-profit systems and digital situated urban gaming (like the work and studies by the Hackable City project in The Netherlands[1]) and art installations, open to the general public and providing a much-needed public space-based, inclusive, interactive and critical dimension to city smartness. Much of the work carried out within the Cyberparks [18] EU-based network is of such a nature, as a variety of initiatives of public interaction design across the globe. Other notable examples include the work of the Media Architecture Institute [19] as well as international networks and festivals fostering and showcasing interactive installations, such as Bristol-based Playable City [20].

It can be argued, however, that even in these more socially committed cases, there remain two dangers. One is the danger of self-referentiality, as the makers and their colleagues may also tend to be the main users and commentators, obviously reinforcing a circular logic in confirming the validity of the projects. De Lange's set of interviews with Playable City actors in Bristol (2015) highlights the positive shifts from a tech-centric to a people-centric view of the smart city, but also seems to reveal a degree of self-containment, where a relatively close and specialised artist community appears to measure the value and impact of installations through the personal/participant reactions of its own members. The other danger is a prevalent focus on the project *per se*, and on its technical or social character, rather than on the initiative as being conceived, analysed and strictly evaluated as part of any wider place-making strategy. Much of such practice of digitally augmenting place is dominated by projects that are temporary and/or mobile installations or applications, conceived to be transferred to or replicated in very different locations. This can be a limit to their active participation in, and design consideration of local context factors, and can lead to often omitting to look into what is left, or permanently affected in the place, once the project ends.

To take just one example of a relatively early – yet still very relevant – digital augmentation project of a public space, particularly relevant in the context of the shaping of 'cyberparks', we can look at the Sonic Arboretum in Montreal. This project, conceived in the mid 2000s, aimed at augmenting the character and functions of a public small park – the Emile

[1] http://thehackablecity.nl/

Gamelin square in Montreal. A parallel digital environment, accessible both remotely and within the physical square itself, augmented the park's physical features – trees and other structures – with digital exchange and interpersonal communication functionalities, with a focus on music files sharing. Whether the project would indeed manage to interestingly articulate the digital and the physical in potentially synergic re-combinations (the virtual, exchange trees were conceived to match the real ones in the park), the focus and design effort was described as a:

" [...] strategy of situating mobile communication activity within the larger framework of urban spaces as ecosystems, in which wireless networks would be more "holistically" incorporated into the environment. This approach allows us to contextualize the flow of information within an expansive stream of other interactions: the flow of people, traffic, food, resources, energy, weather, and ideas." [20]

It can be argued that physical space was therefore still subordinate and playing a background, supporting role. The project's central aim was not to understand, reconceive and re-design the park as a whole, but more about using the park as a rich platform for digital interaction. The same initiative could have been exported and replicated in any other place featuring open space, pathways and trees.

Similarly, the already mentioned and well-known Playable City initiative and network, an idea originated in Bristol with increasing global extensions, aims to put 'people and play at the heart of the future city, re-using city infrastructure and re-appropriating smart city technologies to create connections – person to person, person to city' [21]. This is an interesting and attractive statement, putting an emphasis on some important, social aspects of place-making, yet fundamentally treating physical space as the 'city infrastructure' that can act as a platform or stage for the interactive play-facilitating connections. Playable City installations can certainly be provocative, evocative and useful to encourage interaction and increase the range and frequency of use of specific public spaces, but it is debatable whether they really start from place, have a close dialogue with it and aim at exploiting the possibilities offered by designing it holistically.

TOWARDS A HOLISTIC VIEW OF AUGMENTED PLACE

The distinct examples briefly discussed so far reflect a range of differing views. For instance, the located interaction and urban gaming movement strongly stands in its vision and aims against the top-down, corporate logic of much of the industry-driven smart city set of solutions. The issue in all of them though tends to be that physical space ends up at the supporting and the receiving end of urban change, but does not seem to actively participate in it, or even inform it. In this sense, they are all somehow deterministic towards space. This is impacted upon, saved (or remedied), enriched or it simply provides information that can be analysed. Whilst the more participative digital interventions aim to complement the technology dimension of 'smart' with the social/people layer as rightly

essential to place-making, much less attention is given to taken-for-granted urban space as a third, essential aspect of the smart city.

The importance of looking at digital technology as part of a multi-layered urban 'whole', and the need to imagine and design this whole as one, has of course has been discussed before. Following William Mitchell's intriguing concept of 'recombinant architecture' [22] and trying to expand that perspective with a more operational framework, Thomas Horan stressed the need to look at a whole place design perspective, rather than at digital add-on 'solutions'.

'At one end of the digital place continuum are "unplugged" designs that manifest little or no digital technology in their appearance and construction. Toward the middle of the continuum are various "adaptive" designs, representing modest attempts to visibly incorporate electronic features into physical spaces. Occupying the far end of the spectrum are "transformative" designs: rooms, buildings, or communities composed of truly interfaced physical and electronic spaces' [23].

Horan's language could still be accused of being affected by a residual dualism – as he talks of physical and electronic spaces as potentially separate layers to be combined. But pervasive computing and the so-called *Internet of Things* were very much in their infancy then, and so were spaces and objects that could be seen at the same time as both physical and digital. The concept of 'transformative design' was nevertheless powerful in pointing at the fact that physical space, digital technology, and people (who live re-combined physical/digital lifestyles) need to come together.

And when projects accept the complex challenges that come from exploring extended, re-imagined ways of using public space and defining useful everyday typologies, rather than being add-on digital art or interaction, physical space becomes part of the equation again. An interesting experience and commentary came from the Breakout project aiming at bringing knowledge work into public spaces [24] . The research team observed how issues of digital living (and more specifically, *working* in this case) actually combined with those of physical space organisation and design, and greatly depended on contextual factors. The project did not just stick to a deterministic view of high technology impacting and changing the otherwise static platform of space. Instead, space actively participated in the equation, affected the 'digital', and ultimately the two could not be de-coupled in trying to fulfil the design programme. Once physical space is taken into account and engaged with, with a perspective on inhabitation and (relative) persistence rather than a simply performative 'installation' mode, this calls for proper design considerations such as looking at private/public thresholds; how different activities help or hamper each other; presence of shelter and seating; filtering with building space and so on. All of a sudden, the physical component of place becomes again a very active actor/participant, and sometimes a rather difficult one to deal with, rather than an allegedly docile and passive 'host'. In other words, and however obvious this might sound, if we intend to design augmented places, we would be better off interrogating and articulating all aspects of 'place' and their relationships and affordances, in a holistic way.

APPROACHES TO DESIGNING AUGMENTED PLACES

What can this mean in practice? How can the process of designing augmented places be enriched? This paper has argued so far that, whilst attention is being placed on the need for more bottom-up social participation in the shaping of smart landscapes, much less thought has been invested into re-introducing urban and architectural design principles and knowledge in order to let physical space – and actions involving it – participate directly.

At the start of the 1990s, in an article on remote communication entitled *Being There*, David Brittan mentioned a conversation with Chris Turner, from Olivetti Research Laboratories in Cambridge:

Do you need to see a video image of someone just to be asked out for a beer? "Well, you don't - Turner admits - but don't you think it's rather criminal that you can't?" In his view, the advent of two-way video on computer workstations is a matter of manifest destiny [25].

This we need to move away from: the attitude of deploying technological 'answers' just because we can, or we want to, where there are no clear or well-justified place-based questions after all.

A good starting point therefore is to move away from a solution – and product – based approach, back to an increased awareness of place and the principles and dimensions that can inform its functioning, perception and ultimate shaping.

ASKING PLACE QUESTIONS

Place is complex, and that complex overlapping of aspects, issues and opportunities – if an effort to grasp and understand them is made – can provide important clues towards its improvement by design. Carmona et al [26] for instance identify six interrelated dimensions of our cities as morphological, perceptual, social, visual, functional and temporal layers. Regardless of whether one embraces such a framework, or a slightly different one, a major mistake here would be to think that digital technology constitutes another, discrete new add-on layer. It does not. Instead, it combines in rather intricate ways within the existing dimensions adding more complexity to them. ICT interacts with the form and perception of the city, its social life and milieu, and so on, participating in a process of constant redefinition of relationships. To understand how ICT impacts these dimensions, and how to use it within specific places, we need to 'question' those urban layers.

An example of this line of thought has been discussed by Aurigi [27] when noticing that the otherwise advanced system of public and interactive terminals in the Finnish city of Oulu was deployed as an 'ubiquitous' solution. Questions about usability, information potential, or functionality had been raised – together of course with addressing a plethora of technical issues – yet questions about the specific spaces and places involved, with their character and 'wisdom' had been overlooked. It was noted how "The terminal/hotspot placed in the market square [...] could really play a significant – and significantly unique

– role in a symbiotic relation with the specific place it is part of. As a market square is eminently a space for exchange and transaction (social as well as financial), this character could be boosted digitally by providing place-based opportunities for digital exchange. The possibilities within such an 'augmented market' perspective would still be many and diverse, but they would focus on reinforcing and supporting the place's culture, uniqueness and strengths, rather than providing a 'ubiquitous' service. Context would not just be an opportunity, but it would become one of the central generators of the digital intervention".

Anybody who has ever participated in a design review – be it academic or professional – for an urban or architectural scheme, knows the crucial role that a series of place-probing queries play, towards the formulation of an effective brief and set of design intentions. What relationships (spatial, social and economic) exist there and make the place what it is? What meanings does it have for people? What form(s) does it have and how can it be perceived? How is it used, how do people and things move in it, and what happens there? Who lives there or uses it, and why, and what do they think and feel? How does time affect it? How do environmental conditions affect it? And, more proactively, designers might need to reflect on questions like: is there anything about the place that we need or want to either accept or contrast with, through attitudes ranging "from submission, through symbiosis, to domination" [28]? What potential – as well as conflicts and contestations – does the context have? Can this space play a role in a wider urban strategy? How does it exist and function within a larger place (the neighbourhood, the city, the region...)? These questions, and more, are essential if one is to start exploring how a new urban element – physical, digital or indeed hybrid – could alter the system of relationships already characterising a certain place. They allow us to discover what – if anything – might be needed at all. Yet, these questions are seldom asked before a 'situated' digital project is conceived. Whilst the interface and interaction with 'users' or some of the conceptual aspects of the design are often thoroughly looked at, to echo Horan's early concerns, the deep 'transformational' interfacing with place is easily overlooked.

EXTENDING THE PLACE-MAKING DESIGN TOOLBOX

On the one hand interrogating and understanding place – hence bringing 'space' as a crucial component of it fully back into the picture – can be the first step towards a more sophisticated approach in the design of smart environments. The next challenge however is developing an insight into how the 'digital' participates and integrates with the spatial – in a circular relationship rather than a one-way impact trajectory – in making, or re-making place. In other words, once analysis and intentions are clearer and richer, when it comes to actually designing in a hybrid way, how well are we aware of the possibilities (and threats, potentially) of the extended toolbox we are going to use?

Transformative design calls for seeing high technology not as a self-contained field, but as a set of available additional 'materials' and possibilities, integrating with, expanding and sometimes problematizing the already complex place-making toolbox. Beyond utilizing ICTs for their capacity to extend social networks and public participation through cyberspace,

their potential also needs to be understood within a wider (urban) design perspective, as they can extend and make more fluid a series of very local spatial relationships, perceptions and behaviours.

So, for instance deploying systems that allow communication between remote places or times is not just an exercise in expanding human possibilities, networking and ability to participate, but also an act of altering spatial perceptions by problematizing the 'here' and 'there', and the 'now', never in a neutral way. As many people may experience a loss of privacy and sense of 'refuge' in their homes and bedrooms thanks to always-connected mobile devices [29], ICTs are part of our space, and how those deployed in public places are shaped and used must be part of a conscious act of spatial strategy and design.

When we design spaces we are encouraged to consider the consequences on publicness or privateness and intimacy – and often public-private 'filter' conditions and 'third places' – of the different parts of the environment we are shaping. Yet, when we design augmented spaces, such relationships are still there but complexified and challenged. What was intimate can be made more public through digital means, whilst people can have more opportunities for electronically-facilitated intimacy (and detachment) in very public areas. Similarly, accessibility – both physical and psychological – to places and their characteristics can be re-defined. Relatively invisible or impermeable areas can benefit from a degree of digital visibility and access. The availability and public awareness of various characteristics of place – its history for instance – can be differential, depending on how this is expressed: through physical public signage or inscriptions, pay-per-view exhibitions and information, or electronic layers available only to those who can access them and know how to do it.

Place has always embedded different meanings for different people, and the electronic multi-layering of located information and interaction can further enhance this. However, it can also risk saturation and loss of meaning (too much going on could simply undermine character and purpose of space), or create some kind of interpretative dissonance: whilst the space suggests certain uses and meanings, the digital layer could afford radically different and antithetic ones, as Pawley noted in his discussion on 'stealth architecture' [30]. Whilst this is not necessarily negative – provocation and alternative affordances can be important design moves sometimes – it is crucial that designers of augmented spaces are aware of what they are doing. We can let people hunt for Pokémons anywhere, including for example in a religious building or a cemetery, but do we really want to, and why? What does it mean for that place, for how and why it was designed, and for its character, cultural and practical functioning, and its *raison d'etre*?

CONCLUSIONS

This paper focuses on a gap in research and practice, as the importance and role of physical space and urban design have been looked at only marginally within smart city debates and it suggests – only tentatively – a way forward, by highlighting the need for enriching the two phases of brief-making for, and designing, digitally-augmented places.

In order to formulate an effective brief for improving a public space – or indeed any other environment – regardless of the instruments and technologies used to do this, it is necessary to read, analyse and understand the place and its complexity, so effective intentions can be formulated. Plugging in a project/installation as a simplistic add-on to an allegedly static and passive spatial background is likely to seriously limit its place-making potential. Yet, current discourses and practice tend to facilitate just such approaches, and it would be interesting to conceive and pilot more thorough urban design-based evaluations of 'located' initiatives.

Once a rich and place-based brief has been conceived, the issue of updating our design knowledge to reflect the augmented possibilities also arises. On a speculative and intuitive basis it seems clear that issues of spatial relationships and agency, scale, access and mobility, inhabitation, meaning, perception and memory – and more – which we are accustomed to consider carefully when shaping public spaces, are still important yet often ignored in smart city thinking. On the one hand they should not be jettisoned in the name of an alleged brand-new logic of place dependent solely on the redeeming and innovating power of ICTs. On the other hand they do need to be updated and upgraded to inform design in a re-combined world. It is debatable whether this can be achieved simply through repeated and evolving practice. This upgrading probably needs a thorough research effort. In the 20th Century much intellectual energy had gone into trying to understand articulations, languages and syntaxes of space, and how designers could harness such principles. From Cullen [31] and Lynch [32], to Norberg-Schulz [33] or Hillier [34] – just to name a few – ideas on how space, people and things articulate were usefully framed to help designers make sense of the complexity of places, and to help them become more aware of the potential consequences of their own moves. It could be important now to refresh those efforts and frameworks in the light of the emergence of new variables and extended relationships and possibilities.

Should we therefore augment not just spaces, but our questions about 'place', and design thinking too? In those questions, and an increased awareness and mastering of a series of extended principles for understanding how hybrid space works, lies the quantum leap between just designing self-contained interactions, which at best are 'located' somewhere, and effectively shaping augmented place, making a significant difference for our cities.

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INTRODUCTION

Enhancing Places through Technology

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The rapid diffusion and uptake of Information Communication Technologies (ICTs) presents a new and unique challenge for cities as social life and urban space becomes increasingly (yet unevenly) mediated by new technologies and digital devices. As ICTs continue to infiltrate urban and social realms, there is a pressing need to understand the complexity of this rapidly expanding social and spatial phenomenon. The papers in this collection contribute to an emerging body of work that seeks to understand the relationships between people, the physical urban space and opportunities for place-making, and technology. These three dimensions form the vertices of an important triangle, having far-reaching implications, be it in the development of new technologies, in the understanding of human behaviour and in the definition, and possibly rethinking, of urban spaces. Possibly more importantly, there are significant overlaps, and interfaces, between these three pillars that are investigated by some of these papers.

The proliferation of, and accessibility to, new technologies have raised significant questions to both research and practice. Technology has redefined our lifestyles on a day-to-day basis and our relationships with one another. It has challenged our conventional outlook towards time and distance and required us to re-evaluate our connection with physical space. It has also made us re-question the value of urban space and the extent to which we may still create meaningful 'places' as opposed to anonymous 'spaces' – an increasingly challenging concept given the risk of alienation brought about by technology and that constitutes an unfortunate, but very real, prospect.

The papers present interdisciplinary perspectives from architects, computer scientists, sociologists, urban planners and designers, among others. Diverse approaches to the research field are also offered, including work on new methodologies, new theoretical or conceptual models for the digital era, as well as preliminary studies of peoples' use of, and engagement with, technology in public space. At the heart of these discussions lies the term 'enhancement', understood in terms of the added value that ICT may bring about, contributing to broader quality of life objectives.

The collection of papers in this publication formed part of the *ICiTy: Enhancing places through technology* conference that took place at the University of Malta, 18-19 April 2016. The conference was a mid-term research event for the EU COST Action TU1306 (CyberParks). The play on words suggested by the name of this conference tried to portray the blurriness between 'ICT' and the 'city' (as a representation of the urban realm) that

is being faced today, suggesting the pressing need for it to constitute a research focus in its own right. As such, many of the papers in this collection present works-in-progress and report on the preliminary analyses of data. The book of conference proceedings has three parts.

PART I: DIGITAL METHODS AND SOCIAL PRACTICES IN PUBLIC SPACE

Papers in this section deal with recent and novel ICT-tools that have been (or are being) developed in order to research the use of, and user-behaviour within, public spaces.

The paper by Bahillo, Díez, Marušić, and Marušic reports on a pilot project conducted in a shopping mall in Spain, for which a cooperative location network was developed to assist carers in monitoring the position of their dependents, as the latter roam freely in the space. The authors discuss their implementation (in which dependents are outfitted with a Bluetooth low-energy bracelet), and anticipate how aggregated data from the use of such tools could also serve to gain behavioural mapping insights.

In their paper, Duarte and Mateus report on the initial testing of the WAY Cyberparks application, tested in a Lisbon park in June 2014. Park visitors who download this app have their route tracked, and are prompted for location-based feedback about their park experience as they explore the space. Despite some technical challenges, the early iteration of the tool was assessed as easy to use, as the authors express optimism of the tool's potential future effectiveness at guiding the improvement of public spaces.

The paper by Pierdicca et al explores the topic of mobile AR applications for tourism, outlining best practices as well as technical limitations of such applications. These considerations informed the development of an AR module to be integrated into the WAY Cyberparks app. The authors describe the implemention and testing of this app in Valletta, and report encouraging results for the potential of AR as format for future outdoor touristic and learning experiences.

Complementing the previous paper, the paper by Bonnano et al presents a connectivist approach to the design and evaluation of learning in technology-enhanced open spaces. An inventory of relevant theoretical models is provided, highlighting various dimensions applicable to any Smart City Learning intervention, and identifying various types of learning possible within this context. The connectivist model is applied toward the design of two mobile learning activities designed for sites in Valletta, and managed through the WAY-Cyberparks app.

The paper by Artopoulos presents innovative experimental work in which a variety of immersive technologies are employed to create a virtual reality (VR) environment through which to explore a complex historical site in Nicosia, Cyprus. This system allows users to explore the site while navigating through spaces, historical periods, and roles. Ultimately, the aim is to invite diverse users to explore and ultimately co-curate the architectural

intervention of a complex historical setting. In contrast with the typical practice of presenting historical settings as static spaces weighted with a baggage of historical content, the author convincingly argues that historical settings can potentially serve as a stage upon which visitors can actively express and explore layers of memory and meaning. As such, sensitive and skillful historical interventions can advance the value of social sustainability while also re-associating with the everyday life of the public space.

As mobile phone use continues to intensify, the paper by Joković, Dimitrijević, Atanasković, and Dončov offers a comprehensive introduction into the issue ofelectromagnetic frequencies (EMF), which can potentially impact human health. Basic concepts concerning electromagnetic radiation are introduced, and two prevalent sources are identified: cellphone base stations, and mobile phones themselves. Standard measurementand estimation techniques are described, as well and the variable factors that add complexity to the measurement task. The paper mentions how EMF levels are systematically measured in all European countries from time to time, and reports that the measured radiation levels are currently well below the recommended exposure limits. Notwithstanding, this issue (of EMF exposure from fixed outdoor sources) has importance in the long-term risk assessment of populations in public space.

PART II: ETHNOGRAPHIC CHALLENGES AND THE CREATION OF DIGITALLY MEDIATED URBAN SPACES

Papers in this section explore contemporary design research and innovative open space development practices, illustrating the design challenges of new media for urban and landscape design, and discuss cultural and sociological fieldwork using innovative theoretical and methodological approaches, addressing contemporary knowledge about the use of new media technologies in public spaces from an ethnographic viewpoint. The papers thus address three broad themes: research methodology; applied work; and design challenges.

The first paper by Suchocka, Maksymiuk, Kimic and Kołodyńska is an empircally informed paper that explores the main types of Wi-Fi users in urban spaces and their main activities. They focus specifically on the group they call the 'digital natives' – those who are comfortable and familiar with technology and ICTs. Four types of ICT users were identified within this group: those focussed on work; those focussed on entertainment or social engagements; those passing through as pedestrians; and tourists or other such users. Through observations, interviews and an online questionnaire, this study reveals robust empirical insights into the behaviours of ICT users. Importantly, the study found that users of Wi-Fi hotspots are diverse and they approach the space for different reasons. The research will inform designers and design guidelines for urban public spaces with technology.

The role of ICTs in enhancing citizen engagement in decision-making is the focus of the paper by Ivanova-Radovanova and Radovanov. Here, the authors describe a range of initiatives currently being deployed in the city of Amsterdam, The Netherlands. The authors draw on

research carried out with residents in the city of Sofia, Bulgaria, to gauge the reactions of citizens to the Amsterdam examples. The particular aim of this research is to explore whether initiatives may be transferable between differing urban contexts, and what role the specificities of urban context play in the success and/or failure of such initiatives.

The paper by Bull, Everitt and Rieser describes the *Greenview* project which involved the development of an APP for the purpose of creating behaviour change among users, specifically in relation to energy consumption on the university campus. For this project, animated cartoon characters were created to act as virtual mascots in each university building. The APP was developed to elicit an emotive response from users (based on the emotive nature of the 'Tamagochi' concept) as an engaging way of encouraging them to care for the environment. The central premise of the APP is that when energy consumption levels exceeded those on the same day of the previous year, the visible well-being of species would change, thus highlighting to users the increased energy consumption and drawing out an emotional response, with the aim of encouraging a change in behaviour. The authors pilot tested the APP with a sample of participants to determine key strengths and limitations. In all, the team found that the Greenview APP was perceived by users to be friendly, fun and visually attractive. Participants recommended that the APP needed to be more intuitive and interactive, and also incorporate guidance for users to help them behave differently with regard to energy use.

Suchocka, Maksymiuk, Kimic and Kołodyńska present a second paper based on an initial premise that technology and landscape architecture may interact seamlessly, thereby increasing the potential value of public spaces and users' experiences therein. Building on a previous research carried out by the same authors, which assessed users' behaviour and expectations of technology within leisure spaces, and supplementing this with further empirical work, the authors identify salient spatial characteristics that would incentivise users within public spaces and subsequently suggest tangible design and development principles for hotspots, discussed from specific points of view including users, disadvantages of mobile devices' usage, weather conditions, equipment, materials and health condition (comfort and broader quality of life considerations). Following on from this discussion, the authors proceed to provide some examples of proper and of inappropriate hotspot locations. These principles and examples offer useful pointers that could inform both further research and practice, understood in terms of design policy formulation and implementation. The authors make some final observations regarding the attitude of the new generation of 'digital natives' towards technology and conclude that, while the development of appropriate hotspots is an important requirement, one should not forget the rapid rate at which this technology is changing. They reiterate the crucial role played by open spaces in attracting new users, in providing a setting for the interaction with technology to occur and in contributing more broadly to individuals' quality of life, which should remain central to the discussion.

The paper by Menezes and Smaniotto Costa offers a review of the methodologies and questions associated with ethnographic research, and argues that despite the emergence of new data collection methods, the urban ethnographic toolkit remains a valuable research methodology, because it allows for detailed, culturally-sensitive data collection, with a human-centred perspective. As such, the authors propose an analytical ethnographic framework designed to guide further discussion within the CyberParks project. The framework analyses two rich intersections: firstly, the intersection between information communication technologies (ICT) and urban public spaces (UPS); and secondly, the intersection between ICT and processes of planning and citizen participation. The framework offers a set of 7 questions to guide inquiry, and highlights several dimensions of analysis.

The paper by Botteldooren presents a succinct analysis of principles of classical soundscape design, and discusses how ICT might be used in soundscape design of urban public spaces. To introduce urban soundscape composition, the author distinguishes between the categories of 'backgrounded' soundscape, supportive soundscape, and focused soundscape. Whereas consideration of urban sound has often been confined to a question of noise control, the author cites the potential restorative effects that sound can have, and offers innovative examples of interventions in which sound design influences mood and behaviour in urban public space. Finally, the author describes how the evolution of machine listening opens new possibilities for dynamic urban soundscape design. He anticipates an "internet of sound observatories" combined with different types of actuators and interfaces, which could dynamically alter sound elements or the manner in which they are perceived.

PART III: REFLECTING ON THE RELATIONSHIPS BETWEEN PEOPLE, SPACES AND TECHNOLOGY

Papers in relation to this track reflect on philosophical and methodological approaches and illustrate evidence-informed practice that seeks to understand the complex relationships between humans, public spaces and new media development and how it is (or should be) reflected in the urban fabric and place design.

Social media practices and activities, specifically tweeting in public spaces, forms the core focus of the paper by Djukic, Vukmirovic, Jokovic and Dinkic. The authors aimed to explore the connections between users of online social networks and their engagements with urban public spaces, with a specific focus of Twitter. The study reported on in the paper analyses data gathered from several public spaces in the city of Belgrade to highlight the types of public spaces most attractive to Twitter users in the city, by analysing the concentration of users in public spaces. The results allowed the authors to determine the image of the open public spaces perceived by the users, as well as the intensity of users and tweets through the social networks, with the aim to measure the quality of open public spaces and concentration of users.

The paper by Breser, Zedlacher and Winkler draws on a recent project from the University of Graz, Austria, that explored some technical solutions for representing archival sources of information for urban areas in the digital era. Particular challenges for creating digital archives that are explored in the paper are those related to the archive practices of the analogue world. Here, the authors identify problems with the means of classification of the archives, assignments, semiotic systems and descriptions. In the paper, the authors make use of software applications and mobile technologies to offer solutions for overcoming such problems. The overall argument is that there are very real challenges in comparing and transferring analogue methods to the digital world which are essentially related to the modes of practice in digital and analogue archives that are incompatible and this needs to be reviewed and addressed so information and research materials related to urban areas may continue to be archived into the future.

Klichowski and Patricio present recent work from cognitive neuroscience to explore the question of whether the brain really likes ICT tools and being outdoors while using these tools. The aim of the paper is to evaluate concepts that promote technologically-enhanced outdoor activities, such as CyberParks. The paper poses three main questions: Does the human brain really like ICT tools? Does the human brain really like being outdoors? And finally: does the human brain really like technologically-enhanced outdoor activities? The results of the studies presented show that the human brain does not like ICT tools yet; it likes being outdoors very much. At the same time, it was shown that outdoor activities may be encouraged by ICT tools, yet outdoor activities themselves should be free from ICT tools. The paper concludes that, from the perspective of cognitive neuroscience, CyberParks are not a solution that the human brain really likes.

In a similar vein, the paper by Lister evaluates the concept of smart city learning. In the paper, the author draws on data from an examination of learning experiences in two public spaces in the city of Valletta, Malta. It is argued that the measurement and analysis of individually interpreted learning experiences may build a knowledge picture of how learners perceive immersive technology-mediated learning in smart cities. Mobile learning location--based prototypes were developed and implemented in the two public spaces. The author discusses potential methodologies for designing a measurement of the effectiveness of these learning experiences and associated learning design for immersive urban learning environments mediated by mobile and networked technologies. The research aims to contribute to current approaches of urban smart city environment planning for citizen-engaged 'human smart cities'.

The timely research theme of co-creation in urban planning forms the focus of the paper by Mačiulienė and Mačiulis. In this paper, the authors argue that the notion of cocreation may be used in urban planning by treating citizens as active, creative, decisionmaking equals rather than as passive recipients of top-down design. The focus of this article is the creation of a typology of citizen engagement strategies in urban planning, which shedslight on broader issues around the relationship between technology, urban development and

public participation. By exploring and critically assessing case studies of citizen co-creation in the city context, the authors attempt to illustrate how citizen engagement may lead to construction and redefinition of public spaces.

The paper by Patricio represents a unique offering in this collection with its focus on theoretical and philosophical questions about technology. The work draws on the writings of Nietzsche and focusses on the notions of geophilosophy and geoaesthetics. Patricio's paper is an attempt to read the notion of CyberParks through a Nietzschean perspective and regards the implementation of land art and site-specific art projects as further developments of a CyberPark.

Finally, the paper by Vassi and Vlastos examines the interactions between information technologies and urban public spaces, focussing specifically on the road as a key public space. They argue that technology has altered the nature of the road within cities, as well as the nature of urban transportation. While roads traditionally accommodated vehicle traffic, as well as some leisure, social and work activities, the authors argue that technology has enabled private activities to enter into this more traditionally public space, hence blurring the boundaries between public and private. They focus in particular on the ways in which technology has diversified the means of transport available including the advent of car-sharing schemes and bike rental facilities within cities. Overall they argue that technology is reshaping urban transportation and at the same time it is redefining the road.

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PART I
DIGITAL METHODS AND SOCIAL PRACTICES IN PUBLIC SPACE

A Dependents' Cooperative Location Network for Behaviour Analysis in public spaces

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Damjan Marušić

Abstract – *Many dependents such as children, elderly or disabled people get lost or missing, but as dependents, they often lack the skills to protect themselves, and carers cannot keep their dependents in sight all of the time. Therefore, the challenge to be tackled in this paper is to develop a dependents' cooperative location network over which carers could monitor the dependents' positions in real time, giving them more freedom to safely roam within public spaces. Not only in open spaces such as crowded parks or streets, but also inside buildings such as city malls, museums or nursing homes. The aim of this paper is twofold, to create a cooperative and dynamic network of carers over which to monitor the position of their dependents by means of standardised technologies, and to understand how the physical environment could influence dependents' activities by means of behavioural analysis in public spaces.*

Keywords - Cooperative location networks; behaviour analysis; mapping; safety; security.

I. INTRODUCTION

Improving citizens' mobility in terms of their safety and security is one of the major concerns of cities all over the world. Half of the world population is concentrated in cities and by 2050 two thirds of world's people are expected to live in cities. This trend will increase the challenge. Many citizens get lost or missing in cities, especially the children, our Nation's most precious resource, but as children, they often lack the skills to protect themselves. According to the Study on missing children from the European Commission [1] in the European Union: on average, 400 out of every 100,000 children were reported missing within the period 2008-2012 in the EU. Not only the children, but the elderly and disabled people (dependents in general) are the focus of this work. Knowing the dependents' location is the key to knowing that they are safe. However, carers cannot keep their dependents in their sights all of the time. Therefore, the challenge to be tackled in this work is to develop a cloud service over which carers could monitor the dependents' positions in real time, giving them more freedom to safely roam within the public spaces. Not only in open spaces such as crowded parks or streets, but also inside buildings such as city malls, museums or nursing homes. This way, apart from calming the carers down, they would not need to use their cars to move the dependents thus reducing the CO2 emissions, traffic jams, stress and time.

Currently, the market offers four kinds of solutions for positioning the dependent. The first one uses a hose-clip or a wrist-band that integrates a GNSS (Global Navigation Satellite Service) receiver to determine the geolocation of the dependent, and a modem to send the geolocation data to the carers via cellular networks. However, it has a high cost, around 100 €, it needs an extra monthly fee due to the cellular data communication, and it does not work indoors ([2], [3], [4], [5]). The second one tracks the smartphone of the dependent using their sensors. However, it can only be used for those that routinely carry a smartphone, uncommon for the dependents' profile, and its availability indoors is limited [(6] and [7]). The third one uses a low-cost and battery free NFC (Near Field Communication) bracelet, such as the passive RFID (Radio Frequency Identification) technology, that is carried by the dependent and whose position is updated every time the dependent's bracelet is detected by a NFC reader. However, its range is limited to a few centimetres which means that a big amount of NFC readers would be needed to track the dependents [8]. The last one is technology free and thus the cheapest one. It uses a bracelet where the main profile characteristics of the dependent have been written down. However, it cannot track the dependent and the bracelet has to be identified visually [9].

The solution proposed in this work uses a bracelet carried by the dependent. It integrates a low-cost BLE (Bluetooth Low Energy) transceiver which regularly broadcasts a unique identifier (ID) at constant power. Its range depends on the transmission power, but it usually ranges from 20 to 50 metres. The dependent bracelet's position is determined within the range of a carer BLE transceiver, while the position of the carer is assumed to be previously known – if its BLE device is fixed – or estimated by a location engine [10] – if its BLE device is dynamic. Section II describes in more detail the system architecture of the solution and how it tracks the dependent. The city of Valladolid (Spain), involved in the *VyP* smart city initiative [11], has been selected as the test location for the proposed solution. Its city council is highly concerned about the importance of guaranteeing safety and security for their citizens, enhancing the mobility of the dependents in public spaces. Vallsur, which is the largest mall in the city of Valladolid, showed its interest providing its facilities for testing the solution. Section III describes the experimental setup.

Theoretical backgrounds supporting contemporary research addressing activity behaviours and design of public spaces are mostly grounded in environmental psychology, e.g. affordances [12], and behaviour settings [13], but were gradually adopted for the focused purposes of planning or design [14]. Another relevant concept for environmental planning and place design related to user-spatial relationship, referring particularly to spatial problem-solving, is wayfinding. It is cognitively and behaviourally concerned and according to authors encompasses four discrete stages: orientation, route decision, route monitoring, and destination recognition. In planning and design disciplines such inputs are crucial in analysis and design of spatial sequences and their relations into complex territories.

Behaviour setting is defined with the relationship of social and environmental characteristics of places and refers to a standing pattern of behaviour which is tied to a particular place and time [13]. In practice this means that certain types of place, including socio-cultural contexts, elicit certain types of behaviour that are most probably expected and/or predicted. Behaviour maps, records of behaviour patterns in places and a tool for usage-spatial relationships analytics and evaluations [15], are strongly linked with behaviour settings. In a very literal sense behavioural mapping is really the footprint of a behaviour setting or settings. Behaviour settings offer a useful unit of analysis of how aspects of environmental design are related to people's activities in places, and hence, behaviour mapping represents a method and tool for visualising and monitoring usage-spatial relations and can act towards guidance for socially sustainable design.

Behaviour mapping approach is useful if sufficient repeated observation in a place is done. The major value of behaviour maps as a research tool, lies in the possibility of developing general principles regarding the use of space that apply in a variety of settings. Overlapping individual behaviour maps can show some characteristics and changes in using spaces in terms of activities, number of people engaged, gender, and all the other variables that were explored. Thus there is a challenge to set up and promote a monitoring digital tool which can as much as possible unobtrusively function for users' engagement with places as well as the device/tool itself. In the context of shopping areas research for spatial analysis way finding approach and analytic behaviour mapping are seen as challenging to address issues of usage-spatial relationships.

The target users who will benefit from this solution are the dependents living in a medium or large city where security and mobility issues are evident; and the carers who will monitor for their safety. The customers will be the public administrations and nursing homes who are interested in giving the dependent more freedom to safely roam within the public spaces, reducing the costs in security; the malls and commercial stores who look for improving their services' offer and advertisement; and the museums who look for knowing which area features are most visited and what not. The stakeholders that are interested in facilitating the implementation of the solution are the carers; they want to know where their dependents are at all times. Their cooperation is crucial to enlarge the coverage area. The city councils look for improving dependents' mobility in terms of their safety and security. The city malls and commercial stores want the carers to spend their time shopping instead of taking care of the dependents. Besides, both city councils and stores could gather information about the behaviour of the people within the city, mall or store for future big data analysis.

II. SYSTEM ARCHITECTURE

A back-end processing cloud service has been developed in order to provide a front-end consisted of a set of web services and a mobile application. The solution is based on a cooperative network of confidence devices. It defines two users' profile with unique

identifiers (ID): confidant, assigned to the carer, and dependent assigned to the child, elderly or disabled. The confidence devices could be dynamic such as smartphones, smartwatches or tablets; or fixed, deployed at strategic locations such as parks or streets in open spaces; and doors, stairs or rooms in indoor environments. The position of the fixed devices is assumed to be previously known, whereas the position of the dynamic devices is estimated by fusing the information gathered by its sensors (GNSS, BLE, WiFi, etc.) which were integrated for non-localisation purposes, but that may be exploited to this end, for both indoor and outdoor public spaces. The confidence device integrates a Bayesian framework that considers both the sensors' information and the dynamics of the confidant. This way, the dependents' position will be estimated by processing the received signal strengths (RSS) gathered at the confidence devices in range of which positions have been previously estimated/known. Therefore, each confidence device will update periodically a table with its ID/position, and the ID/RSS of each bracelet in range. All the confidant tables are sent to the command and control centre (in the cloud) where the position of the dependent is computed using once again a Bayesian framework which in this case considers both the RSS and the dynamics of the dependent. The higher the number of confidence devices, the larger the coverage of this network and therefore the higher the probability that a dependent will be accurately positioned.

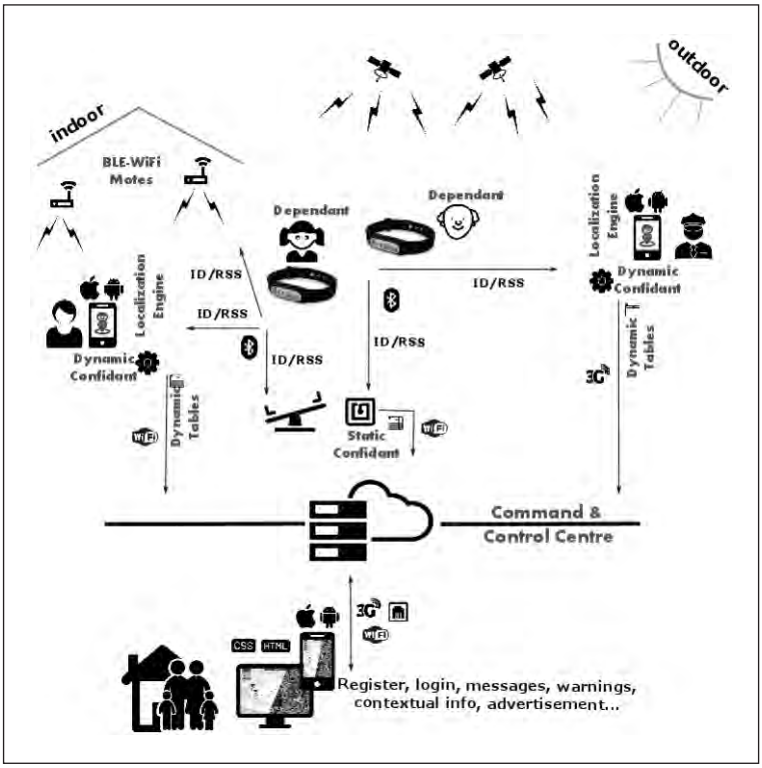

Fig. 1. System architecture. A back-end processing cloud service has been developed in order to provide a front-end consisting of a set of web services and a mobile application.

Fig. 1 represents the main components which describe the system architecture, and the flow chart of the data. These main components are the low-cost BLE bracelet, the BLE-WiFi motes, the mobile application and the cloud which hosts the command and control centre.

A. The BLE bracelet

Fig. 2. The BLE bracelet.

The bracelet integrates a BLE transceiver aiming to broadcast the ID beacon which unambiguously identifies the dependent, the higher the transmission power the higher the coverage but the lower its battery life; an accelerometre aiming to control the time interval between ID beacons, the higher the dependent's activity the lower the time interval, and vice versa; and a vibration sensor aiming to warn the dependent that something happens.

B. The BLE-WiFi Mote

A number of confidence fixed devices have to be deployed to guarantee minimum system coverage because it depends on the network of confident devices, and the dynamic confident devices such as smartphones depend on the number of enrolled carers. Fig. 3 shows a fixed device, it integrates two wireless technologies: BLE and WiFi. The BLE acts as the interface between the dependent (the BLE bracelet) and the carer (in this case a fixed mote), while the WiFi acts as the interface between the carer (in this case a fixed mote) and the command and control centre hosted in the cloud. Both interfaces share a buffer to interchange the data. The BLE interface fills the buffer with the selected BLE IDs and its corresponding RSS belonging to the enrolled bracelets. The WiFi interface empties the buffer whenever the IDs/RSS info is sent to the command and control centre. The BLE-WiFi mote could be powered by a battery supply or directly to the mains power depending on the environment. Likewise, the command and control centre could send messages to the BLE-WiFi motes aiming to restart them, update their firmware, change their state between idle and wake-up, etc.

Fig. 3. BLE-WiFi mote.

C. The Mobile Application

The core of the mobile application is the localisation engine which performs seamless localisation estimation of the carer's device in real time by fusing the information collected by all of its sensors. Nowadays, the smart devices such as smartphones, smartwatches or tablets already integrate a GNSS receiver, a WiFi and Bluetooth adapter, a camera, and most of them will soon integrate other sensors such as the barometre, inertial sensors or the proximity contactless technology NFC. Therefore, taking into account these sensors' information and the dynamics of the carer, a Bayesian framework is used to estimate the position of the carer [16]. Once the carer's position is estimated, several functionalities based on the context would be implemented. Therefore, the localisation engine would be the ideal platform for developing location-based services that provide the carer with context-based information [17]. Among these services, the mobile application mainly allows the confidant looking up the location of his/her dependents, knowing if they go out of the carers' range, editing alarms in order to better control his/her dependents, and pressing the panic button in case of an emergency, i.e. a missing dependent. If this would be the case, the confidant profile could notify the system asking the enrolled users for enabling his/her confidence devices. Thus, the area of coverage will be enlarged. Fig. 4 shows a general view of the mobile application.

D. The Command and Control Centre

The aims of the command and control centre are to remotely track the position of all the carers and dependents, edit alarms, control the fixed BLE-WiFi motes, and analyse the behaviour of the users. As explained earlier, the position of each dependent is computed in the command and control centre so each confidence device will send periodically a table with its ID/position, and the ID/RSS of each BLE bracelet in range. A Bayesian framework is used to estimate the position of each dependent considering both the RSS and the dynamics of the dependent. Furthermore, this command and control centre could provide the services

based on the context, such as offers, advertisement, advice, etc. Fig. 5 shows a general view of the command and control centre.

III. EXPERIMENTAL SETUP

Vallsur, which is the largest mall in the city of Valladolid (Spain) has been selected as the test location for the proposed solution. This mall is highly concerned with the importance of guaranteeing safety and security for its clients, enhancing the mobility of the dependents into the mall. The experimental setup took place in the second floor where 15 BLE-WiFi motes were deployed trying to cover the common spaces. The test consisted of five dependents and three carers. Fig. 5 shows the position of each dependent in real time over the mall second floor plan. This view can be only seen by the guard of the mall because the carer can only see the position of his/her dependents (see Fig. 4). Additionally, as it is shown in Fig. 5 three alarms were defined, two of them related to dangerous spaces such as the exit of the mall and the access to the lift and mechanic stairs, so every time a dependent would enter into those places an alarm would be sent to the corresponding carer. The last alarm was defined in a recreation area so every time a dependent would exit that place an alarm would be sent to the corresponding carer. Another kind of alarm is shown in Fig. 4; as can be seen from the mobile application view, one of the carers has one dependent out of range and the other within range.

The experimental evaluation of the solution proposed in this work allows the stakeholders to validate the system. Carers could monitor the dependents' positions in real time, giving them more freedom to safely roam within the mall. In this case, their cooperation was crucial to enlarge the coverage area, thus the system consisted of 15 fixed confidence and 5 dynamic confidence devices. The mall gathered information about the behaviour of the people within the mall which helps them to improve their offer and advertisement. Finally, the commercial store owners and managers observed that the carers were more focused on shopping instead of taking care of the dependents.

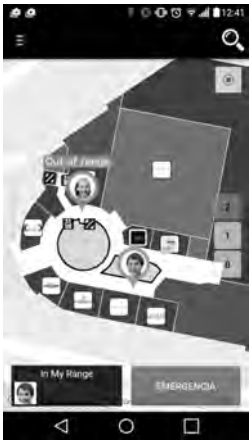

Fig. 4. Mobile application view.

Fig. 5. Command and control centre view.

IV. DISCUSSION

Beside the main goals of such tools providing safety and supporting comfort of people using various places (well-known, less-known, crowded, noisy, etc.), such tool can provide information for spatial-behaviour analysis to inform better practice in design, maintenance as well as surveillance of places. Theoretical backgrounds supporting contemporary research addressing activity behaviours and design of public spaces are mostly grounded in environmental psychology, e.g. affordances [12], and behaviour settings [13], but were gradually adopted for the focused purposes of planning or design (e.g. [14]). Analysing affordances is aimed to understand how the physical environment could influence individuals' activities; whereas behaviour settings refer to regular patterns of behaviour, specifiable by time and place and dependent on the physical characteristics of the place and prescribed social roles for what is expected to happen there.

A further stage of this project foresees the implementation of behaviour mapping-related methods to provide a variety of information about dependent-carer-spatial relationships. Such relationships will be examined on an individual basis, studying each single situation, analysing distances and characteristics of places between carer and dependent to address ease of wayfinding between them, as well as legibility of sequences of places they are involved with. Studying all dependent-carer behaviour patterns in the given area, the project will address cumulative carrying capacity of place for ease to navigate through the place and search for spatial clues, where it is more likely that people could get lost or confused, and how these clues could be similar for different users; different types of dependents and their carers. Thus it is assumed that the implementation of the system (Cooperation Location Network) discussed in this paper can significantly improve information and knowledge about (vulnerable) users in their environments and help to create inclusive design guidelines or recommendations for safe and easy-to-navigate places.

In its essence the ICT approach discussed in this paper is behaviour mapping-based. Originally, behaviour mapping, grounded and well used in the field of environmental psychology [18] is focused on recording behaviour as it occurs in a designed environment. Behaviour map is a product of observation and a tool for place analysis and design at the same time, where spatial features and behaviours are linked in both time and space. Chronologically, some of the most common ways, usually applied in indoor spaces, were systematically writing notes and filling formatted tables, mostly having no connection to actual layout of the observed place. The development of photo-video techniques influenced the latter methods of recording and map production. Nowadays ICT development is forthcoming, offering various ways of recording people's engagement with places. This issue is at the core of this paper, discussing ICT tool, its suitability for automatisation of behaviour mapping, both as process of data collection as well as analytical means.

Authors in [15] discuss three types of behaviour maps regarding their emergence or production: manually (drawn behaviour maps on paper prints produced at sites); semi

ICT-based (digitalised, transmitted manual behaviour maps into their geo-positioned digital version); and ICT-based (GPS device-based behaviour maps, web public participation GIS-based behaviour maps produced in virtual environment). Irrespective of the type to provide a highly informative database, the process of recording behaviour itself needs to be as condensed and inclusive as possible. Accordingly, attributes such as the type of activity, the users' gender and age, duration of the activity, time of the day of occupancy, time of the week of occupancy, movement direction and weather conditions at the presence of the activity; all describe an observed activity in a place. Hence, a coding and counting system needs to be selected before a technique's implementation is addressed. Thus mapping preparation includes a list of some anticipated activities, their assigned symbols and additional coding (e.g. duration, age group). However, the list of anticipated activities needs to stay open-ended for any possible new activities to be added, and attached symbols for these unexpected or infrequent activities to be developed in the course of the observation.

Having gathered behavioural information in time and space, several types of analyses are possible: from straightforward and descriptive in nature such as: How many people access the public space averagely every day?; to more space oriented, such as: Which is the area that is most utilised during weekends?, or Which area features tend to foster exploratory play in children? In this respect the aim of this paper is to provide socially informed concepts and measures for public spaces and to show a potential which ICT driven tools can have for recording and evaluating behaviour patterns and their characteristics; not only to provide safety measures but to address thresholds and evidence-based guidance for urban planning, design and architecture in order to work towards quality of living in cities and towns.

V. CONCLUSIONS

The cooperative location network that has been presented in this paper shows a new service over which carers could monitor the dependents' positions in real time, giving them more freedom to safely roam within the public spaces. Besides the main goals of such digital tool providing safety and supporting comfort of people using various places (be them well-known, less-known, crowded, noisy, etc.), such tool can provide information for spatial-behaviour analysis to inform better practice in design, maintenance as well as surveillance of places. Behaviour maps provide a shorthand description of the distribution of behaviours throughout a place. They are useful if sufficient repeated observation in a place is done. The major value of behaviour maps as a research tool, lies in the possibility of developing general principles regarding the use of space that apply in a variety of settings. Overlapping individual behaviour maps can show some characteristics and changes in using spaces in terms of activities, number of people engaged, gender, and all the other variables that are explored. Focusing on safety and comfort in places, they can also help to provide empirical knowledge about way finding and vulnerable users'

difficulties in specific user-place or user-user situation in the observed setting. Thus there is a challenge to set up and promote a monitoring digital tool which can as much as possible unobtrusively function for users' engagement with places as well as the device/tool itself.

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