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Building City Mirrors: structuring design-driven explorations of future web-based technologies for local development

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This paper presents the design-driven approach applied to investigate how web-based technologies can support local development actions in urban contexts. The key elements of this approach are a design proposal, a conceptual framework working as knowledge infrastructure for the design and research explorations, and a research strategy for systematically investigating the variations of the design proposals and the different aspects of the conceptual framework. The design proposal of the City Mirrors envisions a multi-actor, multi-purpose, and multi-scale digital environment reflecting the key aspects of city development processes. The conceptual framework associated with the proposal is based on the three axes of Users' representation, City Ecosystem and forms of technological support. The research strategy is developed across multiple case studies to analyse the practical implications of proposing alternatives to current technologies in various settings and intervening in the city context through different types of web-based technologies. Relying on these three components, the presented approach addresses the design problem of web-based technologies supporting competing goals and a wide range of applicative scenarios in its explanatory and prescriptive aspects.

Keywords: Smart City; Web-based technologies; Conceptual Framework; Research Strategy

1 Introduction

Digital technologies are nowadays loaded by the highest expectations concerning the growth of cities, their future sustainability and the improvement of their resilience. Indeed, digital technologies are seen in urban contexts as the potential solution to address the social challenges associated with the on-going demographic and socio-cultural transformations, the environmental challenges due to climate change, and the economic challenges determined by the tied interdependence between local and global phenomena. Nevertheless, digital technologies are not yet driving radical changes in the way city activities are planned, managed and governed, and even less in the way people interact in cities to collectively

address shared challenges. In other words, digital technologies intended to support city activities are still marginal in running public and private services, implementing projects and initiatives, transforming the built environment, making policies and plans for the future, orienting the economic investments on local businesses, working on community development and producing an actionable knowledge to trigger structural social and economic innovations at local level.

When we refer to digital technologies for cities, it is essential to clarify the distinction between smart city technologies and web-based technologies for better understanding the different reasons of their marginality.

Smart city technologies include applications based on Internet of Things (IoT) devices, sensors, big data analytics, geographic information systems, virtual reality [Lim & Maglio 2018a] and recently also artificial intelligence solutions. All these technologies are primarily oriented to *"connect things to people"* [Lim & Maglio 2018b] and remain primarily aimed to monitor the physical environment of the city, in particular in "hard domains" such as resource management, mobility, energy, building, instead than "soft domains" such as living, government, educations, economy and culture [Neirotti et al. 2014]. This characterisation of smart city technologies does not provide support to a significant part of the dimensions of people and communities, local governance, well-being and economic development that constitute fundamental axes of all recent smart city frameworks [Nam & Pardo 2011, Lee et al. 2014, Joshi et. Al 2016, Fernandez-Anez et al. 2018, Yigitcanlar et al. 2018], and more in general to new people-centred paradigms for smart cities [Concilio & Rizzo 2016, Lara et al.2016, Schaffers et al. 2011].

Differently from smart city technologies, web-based technologies already had a profound impact on the way people live in the city, organise their own activities and made decisions at the individual level [Aurigi 2016, Finck & Ranchordas 2016]. Web-based technologies include a wide range of systems such as sharing platforms (e.g. AirB&B, Uber), social networking sites (e.g. Facebook, Twitter), location-based services (e.g. Google Maps), community forums, but also e-gov services, voting tools, self-organisation applications and so on. The common point of all these web-based technologies is that they are explicitly meant to connect people through information exchange, enable people to learn, activate relationships. However, nowadays the potentialities of web-based technologies (in terms of versatility, flexibility, pervasiveness and accessibility) are deeply underexploited to permanently infrastructure collective actions, support city dynamics and enable distributed social change processes.

Against this background, the role of design is essential to unlock the potential of web-based technologies (besides being accessible and pervasive) as instrument intrinsically oriented to build bridges among people and therefore able to bring to life new human and social oriented smart city visions. Indeed, a new design space to be explored in the current technological landscape is the one of web-based technologies intentionally designed to support local development actions by configuring an environment helping people to collaborate for addressing shared city challenges.

This paper presents the research approach structured for exploring this design space along four years of activities (from 2015 to 2019) by using design-driven methods associated to a

conceptual framework developed accordingly the three axes of people, city and role of technology in mediating their interactions. This approach had been applied to:

- studying the implications of potential alternatives to the logics of existing web-based technologies with applications in urban context
- understanding users' needs, applicative scenarios and forms of support expected or required from these alternative web-based technologies in city dynamics
- identifying the key barriers, issues and constraints for their design, development and adoption.

The next sections are going to explain:

- the problem framing, and the definition of a design proposal associated to a conceptual framework for systematically explore the design space of web-based technologies intended to support local development actions (section 2)
- the strategy composed to investigate the different components of the conceptual framework by instantiating the design proposal in three artefacts used as case studies (section 3)
- the implementation of the design and field activities for exploring the design space defined by these artefacts (section 4)
- the analysis of the results and implications of using design-driven methods in the research process aimed to understand how web-based technologies can support local development actions (section 5).

2 Problem Framing, Design Proposal and Conceptual Framework

Local development actions are types of actions relying on groups, organisations, communities, classes of stakeholders operating within and across personal, professional and territorial networks. These actions are always interrelated and interdependent from other actions, and often a plurality of goals drive their implementation, both because of the multiplicity of the involved actors and the multiple dimensions of city activities considered in their social, cultural, economic aspects. Respect to these characteristics of local development actions, the main problems of current web-based technologies can be summarised in:

a) misrepresenting social structures in urban context by focusing on users as individuals instead than as part of multiple fluid social entities

b) misrepresenting the city ecosystem as a composite mosaic of unrelated pieces instead than a complex living organism in which each part is interdependent from others

c) misrepresenting local actions as a multitude of mono-purpose flows instead than actions driven and implemented for several coexisting or even conflicting goals at the same time.

For instance, the multitude of web applications for parking or traffic monitoring or bike sharing is oriented to support individuals, but very little the coordination or cooperation among individuals. In addition, these applications usually do not integrate the wide range of

mobility-related services provided by different actors operating at the local level. The narrow focus of this kind applications therefore misses also the chance of enabling the coordination between different services and their users to achieve broader goals such as sustainable mobility in cities.

Overcoming the three forms of misalignments between the logic of local actions and their representation on web-based technologies is a design problem. Indeed, this problem matches all the three conditions defined by Gleasurea [2015] to identify a design problem, because of:

- the lack of effective existing solutions to address these misrepresentations
- the lack of artefacts and theories allowing to explore the practical implications of proposing alternatives to current technologies under their analytical, explanatory, and prescriptive aspects
- the impossibility of studying alternative conditions through observation only, because issues and peculiar phenomena associated with the potential uses of web-based technologies in local actions could become evident only through an attempt to change them by using artefacts to make these issues and phenomena evident.

In addition to these three conditions, designing web-technologies intended to support local development actions is more specifically a "*deep design problem*" that requires a comprehensive understanding of the systems and processes to deal with [Deming 2018], that in this case are city dynamics and local processes. This understanding can be built only by combining *"design practice with robust intellectual inquiry"*, knowledge production and its translation in artefacts and vice-versa, reflection on complex social and political issues with experimental attitude [Manzini 2011]. This condition implies that the study of alternative web-based technologies is carried out by joining design and research, theory development and empirical explorations, with the awareness of dealing with social and political issues more than just technological ones. Indeed, the application of design-driven methods for analysing the problem, collecting the needed information and elaborate them in operation form is a path functional to extend our knowledge of the constraints, issues, needs, challenges posed by city dynamics to the development of future technologies.

The starting point to explore this design space had been the formulation of a *design hypothesis* [Cross 2006] based on the principle that web technologies intended to support local development actions should provide at least a representation of users, city context and urban activities reflecting the logic of local dynamics. This principle is expressed through the design proposal of the City Mirror, intended as a web-platform representing social structures, city systems and local actions as they are configured in an urban context by outlining a digital environment that is multi-stakeholder, multi-scale and multi-purpose.

This design proposal of the City Mirror is the core of the conceptual framework developed along the three dimensions of the user, city and technology to explore and describe a digital environment where:

- The Users' identities are layered accordingly to the plurality of social roles covered by users in groups, organisations, communities, classes of stakeholders, across personal, professional and territorial networks. The coexistence of users seen as agents of the social structures to which they belong create a multi-actor environment [Fig.1].

- The City ecosystem is considered as composed by three intertwined physical, functional and social systems and “in-between spaces” corresponding to values and identities, resources and needs, relationships and practices. Each system and intermediate zone can be analysed at different scales, that in urban context range from the building scale to the neighbourhood up to the metropolitan scale [Fig.2].
- The forms of support provided by technology to local actions are classified in support to coordination, cooperation and collaboration practices, within the specific processes structuring each specific action in a short, medium, long term perspective. Each form of support reflects the plurality of purposes of the actors involved in local actions, as well as the level of potential convergence [Fig.3]

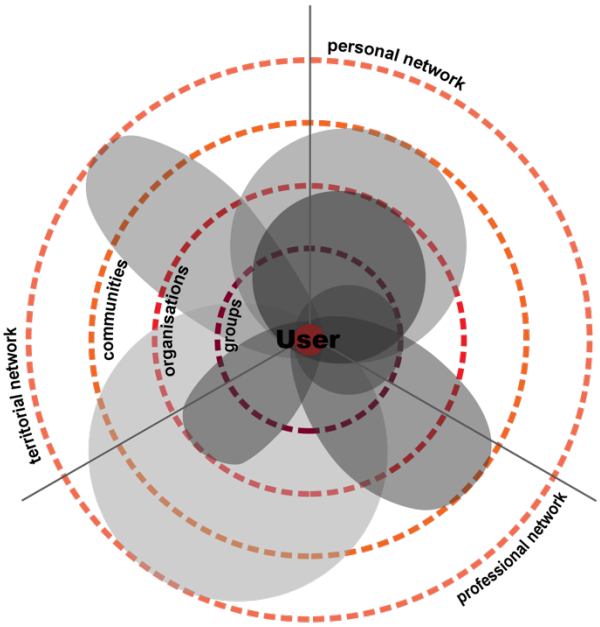

Figure 1: Layers of the users’ identities in the conceptual framework of the City Mirror

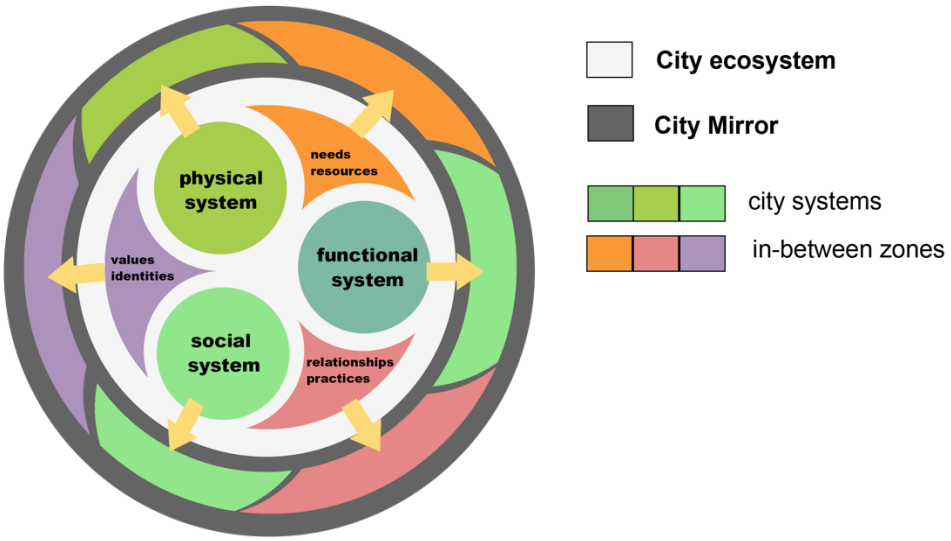

Figure 2: Components of the City ecosystem in the conceptual framework of the City Mirror

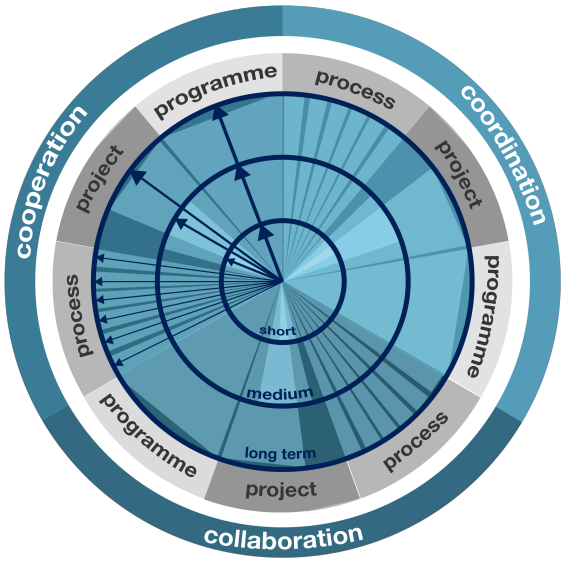

Figure 3: Schema of the forms of support of technologies in local actions within the conceptual framework of the City Mirror

The design proposal of the City Mirror had been used in this approach as a tool critically constructed for investigating the problem under study in its empirical and design aspects concerning:

- the interdependence between users' representations, urban context, city activities and role of technology in between
- the structure and management of the design process of a City Mirror considering the challenges of addressing the needs of multiple stakeholders, multiple domains, and multiple scales of actions to formulate a coherent solution to them.

The conceptual framework associated with the proposal of the City Mirror worked as a knowledge infrastructure to bind real phenomena and design solutions, empirical and theoretical findings. From an operational perspective, this framework allowed the organisation of the empirical and design findings coming from field activities in an organic way, despite the diversity of settings, goals, contexts addressed and analysed by the research.

3 Research Strategy

The City Mirror proposal had been studied by structuring three case studies intertwined to the design process of three web-based technologies focused on city applications with local development aims: a civic social network, a collaborative governance platform and a city open data portal. Each one of these technologies instantiated the design proposal of a multi-actor, multi-purpose and multi-scale digital environment to mirror the structure and nature of city dynamics in local actions.

The strategy to investigate City-Mirror-like technologies had been developed as a continuous transversal activity within and across the three case studies, by keeping a research agenda partially independent by the design and development process of the three platforms and exploiting these design processes to explore in-depth and in different setting the possibility of defining alternative web-based technologies for cities.

This balancing between research explorations and design management was based on overlapping the conceptual framework of the City Mirror to the “contingencies grid” of each case study, given by the goals of the projects to which it was associated, the context of intervention, the involved partners and stakeholders, the scope of the technology in itself, the design phase for the activities to be performed.

For each case study, the exploration space was the results of the overlapping areas between the layers and axes of the conceptual framework that the specific project would allow investigating and the specificities of each project, design process and context of intervention. In other words, each case study had been used to explore the nature of interactions in one city system and its adjacent “in-between spaces”, to analyse the needs and implications of representing a specific subset of users ‘identities in urban actions, to identify the constraints of the preferential forms of support expected by the specific technologies in the applicative scenarios associated to the case study [Fig.4]. The exploration of all the components of the conceptual framework along the three axes of users, city and technologies had been covered project after project, and case study after case study by covering a subset of its components at the time.

As regarding the axis of the City context, the first case study primarily covered the interactions with the physical system of the city taking into account also the resources and values associated to it, while the second and third case study had been respectively focused on the functional and social system of the city. This does not mean that in the research activities we do not considered the totality of city systems as a whole, but that most of the knowledge generated within one case study is traceable back to the constitutive elements of one city system because of the specific goal of the platform, its functionalities, its interfaces, its applicative scenarios and so on.

Similarly, as regarding the layers of user’s identities, the first case study focused on groups, communities and networks, while the second case study addressed mainly the needs of organisations and local communities, and the third case study allowed to analyse groups, organisations and network of organisations. As regarding the form of prevalent forms of technology support, the three case studies provided the opportunity to investigate respectively constraints and schema of coordinative, cooperative and collaborative activities in local actions.

By looking at the three design processes of the case studies, it is important to highlight that the research activities implemented within each case study covered primarily one of the macro-phases of the design process of the technologies under study: pre-design, design, or evaluation phase. Indeed, as indicated by Wulf et al. [2011], one of the major limitations of research concerning the design of digital artefacts is the focus on one only phase of their design process because of the timing of projects, funds availability, resources and opportunities to continue the research for an indefinite time. Building on this awareness, the research strategy to carried out this work tried to overcome this limitation by using the three case studies as distinct units covering the entire design process. The fact of dealing with proof of concepts, working prototypes, and consolidated tools had also been used for gathering more insights on the design constraints in the three situations.

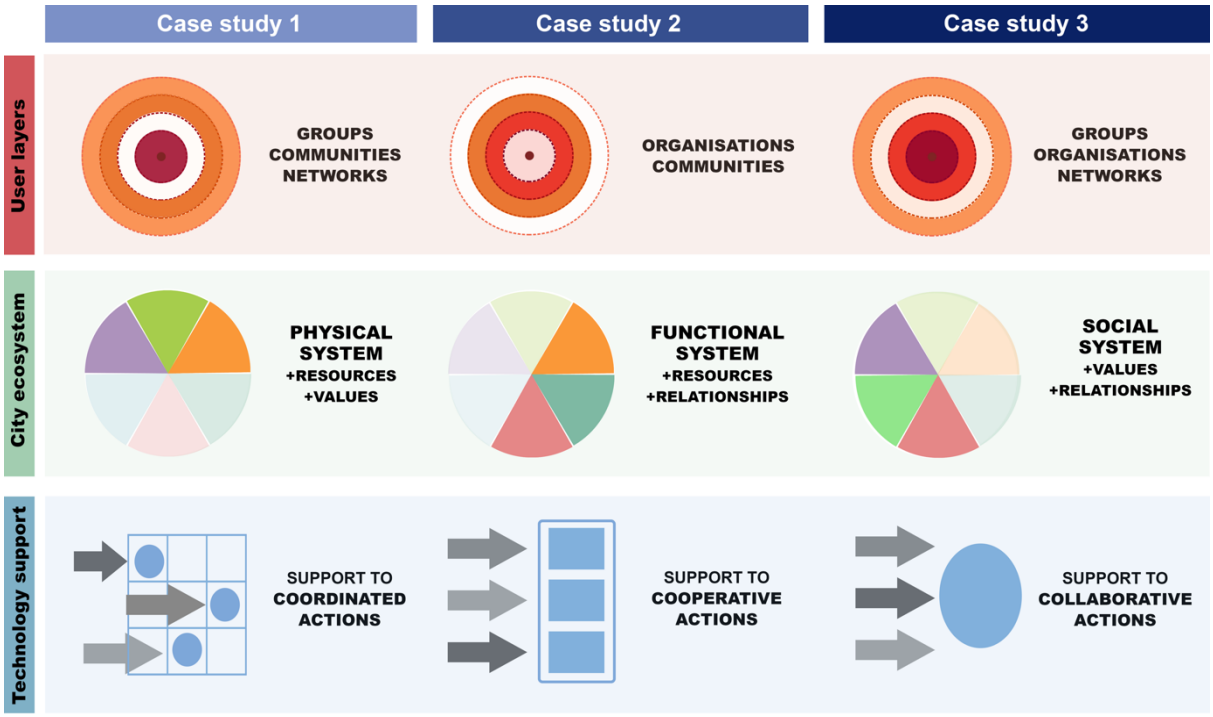

Figure 4: synoptic view of the case studies

The three case studies respectively provided the opportunity to study:

- the intrinsic constraints of the socio-technical context in which the artefact should be integrated within a pre-design phase (third case study)
- the difficulties of balancing contrasting requirements coming from contrasting goals and applications during an on-going design activity (first case study)
- the issues of finding appropriate evaluation criteria for assessing the compatibility between the potentialities of the artefacts and the goals of local development actions in a post-design phase (second case study).

4 Case studies

Case study 1 is associated with the design process of FirstLife, a civic social network developed and tested mainly in the City of Turin, Italy. Its scope was to create a new type of social network aimed to support civic activities, public participation, co-production of services by enhancing spatial interactions among users, especially proximity interactions, such as at the neighbourhood scale [Lupi et al. 2016a]. This principle had been translated into the design of a platform in which the main interface and way to access to contents was through the map, a spatial representation of users' activities, traced by the user-generated contents they create on the platform. The ambition of FirstLife as a civic social network was to find a way for breaking the mechanisms fostered by global online social networks (e.g. Facebook),

such as the extended user profiling for commercial purposes, the segregation of like-minded users (filter bubble phenomenon), or the engagement-for-engagement (social network addiction). On the contrary, FirstLife wanted to enhance diversity and plurality of interactions as they happen in real life and contribute to the active use of a digital tool for implementing concrete social innovation and local development actions in the city [Lupi et al. 2016b]. In doing so, the design process moved into an unexplored domain in which meanings and practices were to be established on different logics that the existing mass social networks, and these logics required to be discovered, in particular as regards the framing of users as "agents of change" and the city not as space but as "container of actions" shaping places.

The field activities for the first case study relied on the involvement of local institutions, privates, and non-profit organisations in workshops, seminars, contextual enquiries, joint-initiatives and branch projects, for three years, mainly in the city of Turin and in the Piedmont Region (Italy). By using the work-in-progress prototype of FirstLife in real settings, the exploration of the design space of web-based technologies for local development had been conducted across several scenarios including: community and participatory mapping initiatives, urban regeneration projects, management of distributed events in the city, consolidation of sectorial networks at territorial level, service design for local enterprises, public engagement in urban transformations. Beyond the analysis of users 'needs in several different settings, these scenarios allowed us to study the pragmatic of interactive maps in multi-actor, multi-scale and multi-purpose digital environments. They also highlighted the issues associated to map-based interfaces concerning the representation of local coalitions, power relationships, formal and informal hierarchies among city organisations and groups outlining a set of complex constraints to consider in the design process.

Case study 2 had been developed within the project of WeGovNow, a platform for supporting collaborative governance processes in the city [Boella et al. 2018]. Its scope was moving from the paradigm of the e-gov to the one of the we-gov. In other words, from using technology to intermediate the relationship between Public Administration and Citizens, to use technology for building new collaborative relationships between public and private actors to improve the local governance. The proposal of WeGovNow was to implement this paradigm shift by integrating in a unified platform a set of digital tools already existing, such as a deliberative platform, a community mapping tool, a reporting application, a crowd-mapping system, and test the new platform in two Italian cities (Turin and San Dona' di Piave) and in the London Borough of Southwark (UK). The main challenge of designing WeGovNow as a collaborative governance platform was not just to work on technology, but on outlining new governance models through the use of technology. Working on existing platforms for new purposes and new applicative scenarios deeply questioned assumptions and logics under their design, pointing toward alternative solutions and meanings of the available functionalities. At the same time, working on defining new governance models and collaborative services by using technology as a frame helped the partners involved in the process in building a greater awareness of the political, social, and practical implications of design choices.

In this case study, the design space of web-based technologies for local development had been explored by working with the institutional stakeholders of two of the cities involved in the project (Turin and San Dona' di Piave, Italy) on a set of sub-projects and by conducting interviews, workshops, and contextual enquiries with various offices of the local administrations. These activities were aimed to analyse with the stakeholders how aligning

the forms of support provided by the WeGovNow platform to the way city management processes are actually implemented. Building on that, we constructed with the partners four collaborative governance scenarios refactoring the logics of existing tools (without altering their core functionalities) in order to enable, through the new unified platform, new ways of organising and managing public spaces, services, projects.

Case study 3 accompanied the development of a proposal for refactoring MK:Insight, the Open Data portal of the City of Milton Keynes (UK). The main goal of the design exploration for MK:Insight2X was to overcome the underuse of the existing platform by outlining new design solutions to transform the data portal into a tool effectively addressing the needs of different stakeholders operating in the city. The limited use of Open Data portals is a well-known problem affecting this typology of technology [Janseen et al. 2012], and not only the Milton Keynes data portal. This problem is recently becoming more critical at an urban scale where the availability of data tend to be associated with high expectations for data-driven local development processes and, at the same time, with rising tensions related to redistribution of the benefits generated by the access and elaboration of city data [Kitchin 2014]. In order to address this mismatch between increasing requests of data publicly available and the limited use of existing Open Data, the redesign process of MK:Insight2X started from rethinking the components of an Open Data portal, revealing assumptions and practices embodied or hidden in its functioning, or simply not covered by the current functionalities of Open Data Portal. This process had also been grounded on the idea that an Open Data portal requires to be “open” to the needs and practices of people that could make a positive use of data in the activities they implement into the city.

The exploration of new functional configurations for the Open Data portal to support data practices for local development actions had been developed entirely in the pre-design phase of the new portal, driven by the purpose of moving from the idea of a {Open Data} PORTAL to the idea of an OPEN {data portal}. In other words, from a data portal as a catalogue of open data products and centred on the needs of one data producer, to a data portal opened to a plurality of “data activators” and reframing data as a relational medium among local stakeholders. The proof of concept and preliminary prototype of the OPEN {data portal} had been developed as a result of the engagement process that involved city council, public agencies such as health and environmental agencies, businesses, academia, non-profit organisations and grass-roots groups. The representatives of these local stakeholders had been called to explore the design space of an OPEN {data portal} through the construction of visual artefacts outlining a plurality of real scenarios connecting Open Data to local actions. These visual artefacts, built by using cultural probes and storytelling techniques, provided a rich understanding of the relational patterns associated to the production and use of data in the city, as well as on the boundaries and internal rules expected from a multi-actor, multi-scale and multi-purpose city data portal.

5 Recomposing the design space across the three case studies

The implementation of the multi-case study strategy had been based on the sequential development of the three case studies advancing through a double helicoidal process, in which every convolution of the primary helix corresponds to the development cycle of one case study that internally progresses through local cycles combining action, analysis, design, and conceptualisation of contextualised findings [Fig.5].

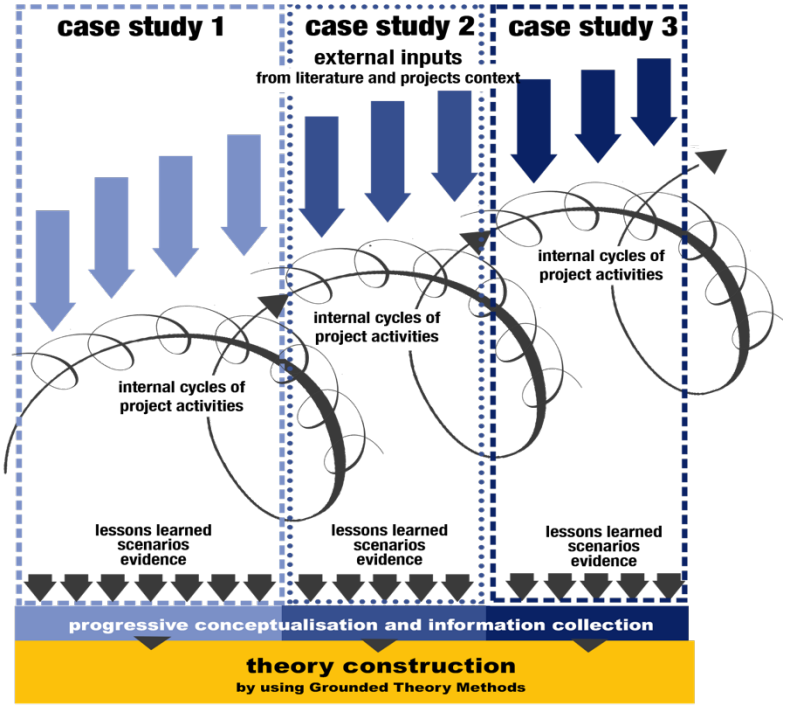

Figure 5: Development process of the case studies

The sequence of the three case studies allowed to progressively move the focus of the research from the analysis of the contextual factors impacting on the connection between web technologies and city dynamics, to the analysis of the processes to be supported, and then to the rules to put in place to make these technologies socially acceptable into a complex relational environment. Similarly, the object of design expanded from the platform functionalities, to the services build on and around the use of these technologies in city activities, and lastly to the more abstract level of the nature of information and relationships activated through the information exchange [Fig.6].

Leveraging on the diverse operational settings of the case studies and the peculiarities of the three platform under development, the recomposition of the design space of city-mirror-like technologies had been progressively done by using the conceptual framework as infrastructure for articulating the different pieces of knowledge coming from the three case studies, as anticipated in section 2. The components of the model of the City ecosystem [Fig. 2] had been linked to the ones of the model of the users' identities and the forms of technology support.

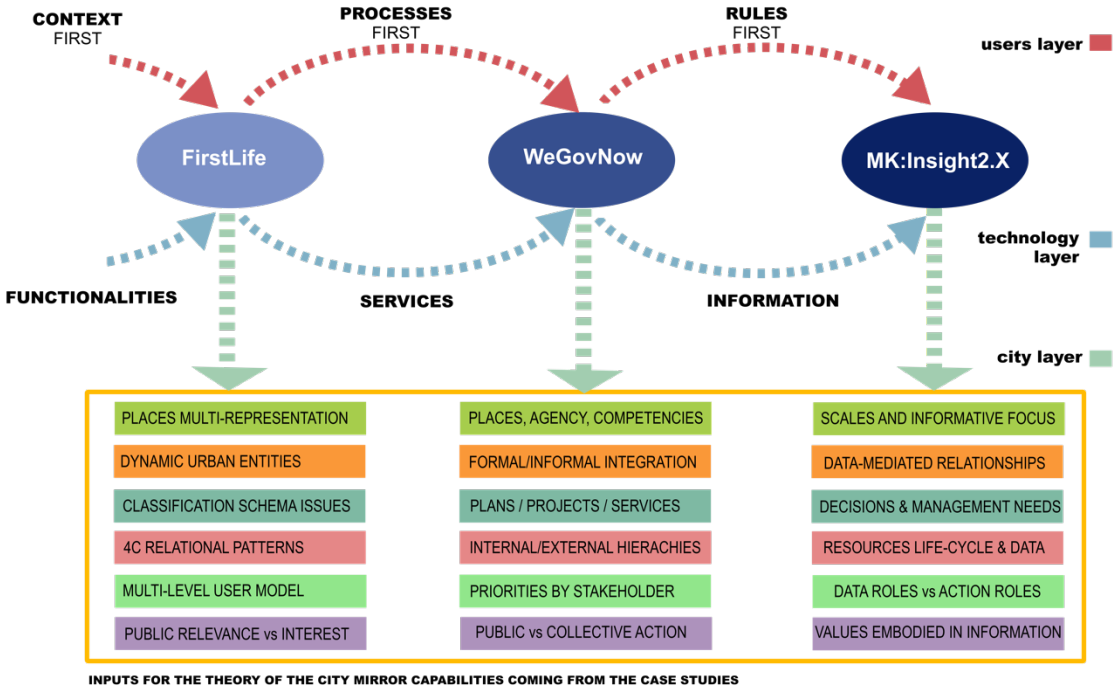

Figure 6: Exploration of the connection between people and technologies in the city across the three case studies

For instance, the representation of the physical system of the city started to be analysed in relation to the different perceptions and languages of different users to understand how to enable the coexistence of multiple representations of places, experimenting and testing various solutions with users and consolidating the insights on this aspect. Then, in the second case study, the analysis of the representation of the physical system of the city explored the aspects related to the ownership and competencies over places, established both formally or informally, and how these affect the online and offline agency of users over these places. In the third case study, the representation of the physical system of the city had been investigated by focusing on the types of information able to communicate the characteristics of these space with a focus appropriate to the scale of action of users. Thus, the sum of the three case studies allowed to explore the representation of the physical system of the city in relation to the perception of the urban environment mediated by technology, the link between online and offline actions in the city implemented by users, and the barriers or tactics to facilitate the communication about the urban environment and actions in the city at different scales providing a deep understanding of this specific aspect. Analogously, the same approach had been followed for the functional and social systems of the city, as well as for the in-between zones of the needs and resources, values and identities, and relationships, as shown in fig. 6.

The lessons learned from the design processes, applicative scenarios and pieces of evidence progressively gathered and analysed had been stratified and systematised by using grounded theory techniques in a coherent theory binding concepts, requirements, and evaluation criteria to inform the design of web technologies reflecting city dynamics by creating a multi-actor, multi-scale, multi-purpose environment [Fig. 7]. The resulting theory organises the capabilities of web-based technologies intended to support local development

actions accordingly to the components of the City Ecosystem. In particular, the resulting theory focuses on the technology capabilities of enabling city stakeholders in:

- "reading the city" by lighting on the richness of places where they live
- "observing the city change" by monitoring shared material and immaterial resources
- "dialoguing with others" beyond organisational boundaries to known what is going on
- "understanding the city functioning" by navigating across practices, services, and interdependences of city activities
- "taking care of the city" by being aware of the evolving local needs
- "transforming the city" by creating a dialogue space opened to competing values.

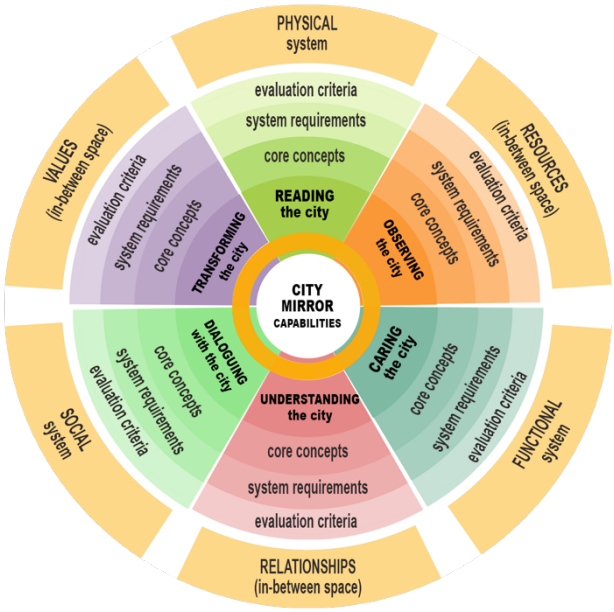

Figure 7: Dimensions of the preliminary theory on the City Mirror capabilities

The ultimate goal of developing a design theory based on the iterative exploration of a design space reflects a common practice in design-driven research, and in particular in Research through Design approaches in the field of technology design [Gaver 2012, Zimmerman et al. 2010]. In this framework, it is assumed that the resulting theory is always provisional [Gaver 2012] and opened to further integrations.

The adoption of a design-driven approach in the exploration of the City Mirror proposal provided the opportunity to combine the three forms of Interaction Design research indicated by Fallmann [2008] for generating knowledge about an alternative future (the possible), the users' needs (the true) and the constraints of the operational context given by the design process in itself (the real).

The presented design-driven approach applied to investigate how web-based technologies could support local development actions reflects also the three canonical roles of researchers in the practice of design-driven research as "constructors of the world they

desire" [Zimmerman & Forlizzi 2014], scholars engaged in tracing how knowledge is generated by intervening in the context through artefacts [Zimmermann et al. 2007] and as "glass-boxes" on the connection between design choices and implications in the applicative context of the artefacts [Jones 1980].

6 Concluding Notes

The value of the design-driven research approach presented in this paper is proposing an example of the exploration of the connections between technology and people in urban contexts coherently pursued across multiple projects, settings, artefacts. The double-core of this approach is in the design proposal of the City Mirror and the conceptual framework based on the three axes of Users' representation, City Ecosystem and forms of technological support. Both are aimed to envisions and analyse the practical implications of proposing alternatives to current technologies under their explanatory and prescriptive aspects.

The strategy implemented to systematically explore the design space of these future technologies across multiple case studies also reflects other two distinctive characteristics of a design orientation to problems. Firstly, the attempt to address complex problems such as local development dynamics in a holistic way, while abstracting, selecting or generalising the multitude of factors impacting on the definition of the problem [Jones 1980]. Secondly, the integration of inputs from a plurality of theories and methods from different disciplines by identifying conceptual and operational convergences, as it had been done in this work bridging the domain of Interaction Design with theories, models, methods of the research in urban planning, urban design and urban studies.

In conclusion, the role of design in this type of exploration is enabling the discovery of new phenomena (not observable without intervening in the context), but also providing support to bring out the tacit knowledge embodied in the practices of city actors. In this way, the adoption of a design-orientation to study digital technologies in cities made possible to outlining new needs [Fu et al. 2011], understanding how pragmatically address conflicts and competing goals of different practices and actors, and tracing new paths for future technologies.

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