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Abstract	Even though extant research has addressed end user involvement in the process of Information Systems' Development within a Smart City environment, it has not done it in its early or Fuzzy Front End phase. Therefore, this paper promotes and describes a concrete big data based service process in which end users and other individual stakeholders are involved since the early phases of development. Researchers used this end user data to define which part of the big data would be opened for developers and citizens in future stages of the project.

Keywords	User requirements - Service development - Big data

Chapter 30
End User Involvement in the Big Data Based Service Development Process

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Abstract. Even though extant research has addressed end user involvement in the process of Information Systems' Development within a Smart City environment, it has not done it in its early or Fuzzy Front End phase. Therefore, this paper promotes and describes a concrete big data based service process in which end users and other individual stakeholders are involved since the early phases of development. Researchers used this end user data to define which part of the big data would be opened for developers and citizens in future stages of the project.

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30.1 Introduction

Information and communication technology (ICT) systems are often developed and studied from a systemic organizational viewpoint—how such systems support organizational activities and processes—rather than how they support individual users' preferences, qualities, and actions. However, ICT systems are not used by organizations but by individuals. Those individuals, end users, and other stakeholders, utilize ICT systems to accomplish their professional and family tasks individually and/or in groups. Contemporary ICT systems should be consequently designed not only from the organizational needs' but mostly from individuals' viewpoints, fostering human characteristics.

Even though there is wide agreement that Smart Cities are characterized by pervasive use of ICT systems, which should help cities make better use of their resources [1], there is scarce research on user involvement in ICT requirements' elicitation within a city-scale dimension.

The Future Cities European project aimed at building research capacity for city-scale experiments in Porto (Portugal) by acquiring and installing critical equipment for developing large-scale test-beds and prototypes in the areas of intelligent transportation systems and urban sensor networks (mobile and static), which would leverage Porto as a natural living lab for smart future city and big data technologies. Thus, this research project involved end users (i.e., which includes citizens and other individual stakeholders throughout the paper) in three main stages of the Fuzzy Front End of the New Service Development process [2]:

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First stage: the main objective was to broadly understand what data (and why) end users would like to have access to;

Second stage: the end users were consulted to define where to locate the static sensors around the city;

Third stage: how do people interact with the city and how would the collected data (and what data specifically) enable the provision of services intended by the city stakeholders.

30.2 Related Work

According to several researchers' (e.g., [1, 3]) view of Smart Cities, the mere deployment of ICT should not imply that a city may be designated as smart since smart initiatives do not only entail technology changes, but also investments in human capital and changes in urban living practices and conditions. Therefore ICT should be rather considered a General Purpose Technology [4], which is complementary to human and organizational capital and whose usage is shaped by political choices and by the urban ecosystem of the citizens, technology vendors, and local authorities, depending on the city stakeholders' needs and habits. There is a clear need to enhance user involvement and user support in experimental research related to the Future Internet within Smart Cities [5]. User participation in information systems development (ISD) is argued (e.g., [6, 7]) as a potential effective practice to achieve various favorable outcomes, including enhanced user satisfaction and increased system quality. Nevertheless, extant research does not usually promote user involvement in the early phases of service development. Therefore, building on positive results from other research areas (e.g., public transportation services) methods for users' input should enhance their proactive participation since the beginning of the discussion in ISD and be adapted to local contexts according to different user needs and conditions [8].

The "open data" movement is pressing urban policy makers to provide their data freely available in a widely used format so that developers can build transit and other applications on top of it. Success has been mixed, as revealed by City-Go-Round, a website that provides access to "useful" transit apps. According to this movement, the website states that as of 2016 only 247 out of 864 transit agencies in the United States had open data, whilst in Estonia, none of 32 listed transport operators provided this service. The goal is clear: city data needs to be provided in an open format, similar to the way in which London Underground transmits its data [9]. Nevertheless, not all of the urban big data collected is equally relevant and so some of it should be selected to be (eventually processed and) opened for developers and end users [10]. Thus, based on a Living Labs approach, the access policy to data should be weighted by project or political deciders and limited to nonsensitive information (e.g., personal or strategic) to guarantee data protection and prevent misuse of the information provided [5].

30.3 Methodology

The research adopted a three-stage approach in order to obtain different kinds of information in distinctive moments of the project from the most relevant stakeholders of the Future Cities European project (i.e., researchers, municipality, companies, and citizens). Each of these stages focused on addressing questions such as Why, What, Where, and How.

30.3.1 First Stage (Why, What)

First, researchers on mobility and urban planning were contacted, while policy makers also demonstrated their strategic and operational (mostly citizen-focused) perspectives. Several meetings took place with six of the most significant research/political deciders in order to understand from a broad perspective of why and what kinds of information would they like to collect from the city. Moreover, in this stage, it was also evaluated the conditions required at the potential locations for the sensors.

Next, a workshop on large-scale city sensing was organized, during which a larger sample of 37 participants brainstormed on possible use cases and pilots. In this early stage of the project, it was important to have an innovative perspective on leading research subjects that could create value both for the project and for the city. Therefore, the participants in this workshop were mostly institutional stakeholders such as researchers, municipalities and startup companies. After an introduction to the project (e.g., essentially to the planned crowdsourcing and urban-sensing test-beds) and to technical subjects (e.g., mobile wireless networks, etc.) the participants used post-it notes to suggest information or services they would like to have access to.

30.3.2 Second Stage (Where)

This stage followed an iterative process with four steps to find the best locations for the sensors:

- Step 1 The high-level locations were selected for each end-use area (e.g., districts, neighborhoods, streets);
- Step 2 Each high-level location was specified in a set of concrete coordinates in order to assess the technical viability such as network coverage and power availability (several locations might be viable in a given street);
- Step 3 The same six stakeholders of the first stage were contacted to rank the suggested concrete locations;
- Step 4 The best viable locations were chosen taking into account several perspectives in order to satisfy most of the stakeholders.

30.3.3 Third Stage (How)

In this final stage of the research study, a qualitative approach was chosen because it can be used to obtain the intricate details about complex phenomena [11] such as cognitive processes that are difficult to extract or learn about through more conventional research methods. The qualitative study was held with the collaboration of the most relevant key decision-makers, who were interviewed in order to broadly understand how do they interact with the city and what do they need to know about it. Interviews were performed to eleven institutional stakeholders, including the municipal police chief, senior academics, startup's CEOs, and heads of municipal departments. In addition, to also include the citizens' perspective, the presidents of an environmental NGO, of a bicycle promoting and of a visual impaired people associations were also interviewed.

The interviews were semi-structured in accordance with a predetermined protocol that aimed at supporting them and at gathering information using open-ended questions, in order to maintain the flexibility for the interviewer to explore other issues that could arise spontaneously during the interviews. The main questions were essentially flexible and exploratory in order not to bias the interviewees' answers. Whenever needed, probing questions were used to obtain further details. The interviews were sound recorded so that the interviewer could dedicate all attention to the interviewees.

30.4 Results

The data collected included information on why and what kind of data would be made available, which would influence the type and location of the sensors required to collect the data, and in turn would influence how to make it openly available for future big data city services. Taking into consideration the iterative process taken to collect information from the end users, extended data results were aggregated into different-level categories using tools such as the Affinity diagram [12].

30.4.1 First Stage (Why, What)

Depending on the type of stakeholder contacted, information on the reasons to collect city data was diverse and focused on their different aims. Even though all stakeholders had the final objective of improving the urban quality of life, the different municipality departments were more focused on the measurement and operational optimization of the environments where people usually are, therefore they were for example interested in counting people in specific areas; traffic planning scientists were mostly concerned with pollution (noise and air) around high traffic areas and with improving mobility; environmental researchers preferred to measure environmental parameters homogeneously across the city despite the density of people around each location.

In this first stage, the results about what kind of data to collect were mostly aggregated into broad categories related to the planned crowdsourcing or/and urban-sensing test-beds of the Future Cities project:

- Crowdsourcing: data essentially related to individual mobility and promoting communication channels between citizens and policy/transport planners;
- Urban-sensing: as this test-bed aimed at involving both mobile (i.e., in vehicles) and static sensors, results varied between trying to use the vehicular network to

exchange static sensor data and complementing static info (e.g., environmental) with mobility updates;

– Both test-beds: mostly associated with merging the data collected from both test-beds.

30.4.2 Second Stage (Where)

Following the results obtained in the first stage, Luis et al. [13] concluded that each data collecting unit might have to include several types of sensors such as mobility, environmental, or video-cameras. Whereas citizens spend more time in certain streets and areas such as parks, sensors should be there located from a people sensing perspective. On the other hand, street-by-street sensing would enable covering the city homogeneously. Taking into consideration the interest of the different stakeholders involved in measuring various sets of variables (e.g., where most people are, high traffic areas or uniform distribution around the city, etc.), decisions on best location had to account for different factors and weights. See Fig. 30.1 for a spatial distribution in Porto of the final location for the 50 data collecting units.

Fig. 30.1. Distribution of the 50 data collecting units' final locations

30.4.3 Third Stage (How)

The data collected in this stage was aggregated into the main categories of information to which the participants would like to have access to. This categorization was revised by Future Cities' researchers during iterative meetings, and the final aggregation of data included the institutional stakeholder and the end user (association) perspectives.

Institutional stakeholder perspective

Main question: What would you like to know about Porto?

Probing question: To what data would you like to have access to?

- Multiplicity of traffic dynamics, Network inference, Multicriteria routes and their optimization, Urban logistics, and accessibility
  - Moving elements
    Direction,
    Position (e.g., length of stay),
    Routes,
    Average speed,
    Accidents (e.g., pedestrian runovers),
    Number of people (e.g., purpose of the trip), and
    Traffic volume.
  - Transportation services
    Available modes,
    Mode demand, and
    Network and frequencies.
- Citizen learning about the city (and vice versa)
  - Citizens' financial availability,
  - Citizens' household size,
  - Citizens' age,
  - Archeology: historical data,
  - Mood sensor index,
  - Smart city index, and
  - Priority areas based on thermal risk.
- Two-way communication channel with municipality/infrastructure manager
  - Public services,
  - Mobility, and
  - Environment.
- People civility
  - Illegal parking,
  - Training of motorized road users, and
  - Not conflicting with other people's rights.
- Security
  - Thefts,
  - Vandalism.
- Climatology, Health and their assessments before/after particular urban changes
  - Indoor air quality,
  - Bioclimatic comfort,
  - Pollens,
  - Particles,
  - Pollution,
  - Sounds,
  - Shadow areas, and
  - Climatology.
    Wind (quadrant, speed, or dispersion),
    Rel. humidity,

Rain,
Fog, and
Temperature.

- Resources
  - Location, Physical accessibility, Point of interest
    Available parks (e.g., times and fees),
    Elderly support,
    Hotels,
    Deliveries, and
    Stores (Status, e.g., open, closed).
  - Energy consumption
    "Automatic light" on in isolated areas.
  - Water consumption
- Data correlations
  - Impact of environment on birds' behavior,
  - Impact of pollution on health,
  - Impact of temperature on happiness,
  - Impact of green areas on health and thermal comfort,
  - Count the number of S. João (municipal holiday) balloons and assess fire risk based on wind direction and temperature, and
  - Impact of environmental indexes on health.

End user (association) perspective

Main question: What is important for an associate in his/her relationship with the city?
Probing question: To what data would like to have access to?

- Geo-referenced mobility information
  - Mobility
    Mapping routes adapted to bicycles (not cars),
    Direction,
    Average speed,
    Fuel use,
    Traffic black spots,
    Volume of traffic,
    Road slope, and
    Type of road floor.
  - Transportation services
    Preferable integration of bicycles in traffic circulation (except for children).
    Multimodal.
      Easier input or output transport in rush hour.
      Positive discrimination (e.g., integrated ticket in app).
- Two-way communication channel with municipality/infrastructure manager
  - Public services,
  - Mobility, and
  - Environment.

- People civility
  - Training of motorized road users,
  - Not conflicting with other people's rights.
- Quality of life
  - Access to employment,
  - Physical accessibility,
  - Culture, leisure,
  - E-accessibility, and
  - Involvement in the community.
- Weather conditions
  - Forecast and estimation of change during travel.
- Resources
  - Pedestrian crossing locations (e.g., vibrating signal traffic lights.).
  - Main points of tourist attraction
    Occupation of public space,
    Petrol stations,
    Bike repair-shops (discounts), and
    Bike fixation/security/covered parking.
- Better public lighting at night.

30.5 Discussion

Even though extant research has addressed end user involvement in the process of ISD within a Smart City environment [5], it has not done it in the early or Fuzzy Front End phase. Therefore, this paper promotes and describes a concrete big data-based service process in which end users and other stakeholders are involved since the early phases of development. The methodology used enabled gathering information on a broad perspective of end users and stakeholders such as professionals, scientists and user associations. Thus, it was possible to understand the intricate details about how do urban stakeholders interact with the city by adopting an open qualitative approach [11] in important phases of research. Otherwise, traditional ISD methodologies [6] would not enable obtaining complex phenomena such as end user cognitive processes and answering questions such as Why, What, Where, and How should city data be collected and made available for its stakeholders.

30.6 Conclusions and Future Research

ICT systems are often developed and studied from a systemic organizational viewpoint, however they should also be developed from the individuals' perspective. This paper involves several individual perspectives, either professional or family ones, and it contributes to a new breadth of knowledge within the big data based service development process.

Future possible research would benefit from using these data results for researchers to discuss Access Platform Interfaces' requirements in order to define which part of the big data would be opened for developers and citizens. Nevertheless, not all of the urban big data collected would be equally relevant and so some of it would have to be selected to be opened according to different priorities.

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