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SMART CITIES: EVENT EVERYWHERE

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DEDICATION

To my husband, Chuchito for his tolerance, love, humour and

Patience. For taking care of our JF over many nights.

To my mother for all the sacrifices she makes each day and for taking the time to make my life happy and memorable.

To my son for being the source of my strength and inspiration.

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I would like to take this opportunity to express gratitude to my parents for the unceasing encouragement, support and attention. I am also grateful to all of the Department faculty members for their help and support.

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

ABSTRACT

SMART CITIES: EVENT EVERYWHERE

Over 70% of the world population will be living in cities by 2050, so cities must be prepared to face the different challenges caused by these new scenarios. Smart Cities arise as a possible strategy for managing and mitigating against the problems generated by the urban over population and rapid urbanization. However, the different issues that this can introduce however need to be considered, when the smart city not be controlled properly.

One of the most critical challenges is the availability of information in different formats, since this can cause some issues when this information needs to be integrated with data from different sources and formats. Correct information will enable the correct decision to be taken at the right time. This digital information needs to be available to connect the public and private applications to allow them to make the best decisions.

The research attempts to provide a big picture from the literature through a Systematic Literature Review about the smart city and the existing standards topics for interchanging data through Smart City Apps, since there is a drastic increase in the number of Smart City Apps that are built every year. Some governments are concerned about the loss of funds as a product of repeated or redundant construction of applications.

From the SLR analysis, we found 107 primary papers from three different sources, of which 21 were relevant for this research. In the relevant papers we found 13 different standards. The most popular standards are Web Services and RDF with 13 and 10 appearances respectively. On the other hand, PAS and MQTT standards are the least popular when discussing Smart City. Additionally, at the applications level we found the following standards: CitySDK, iCity and FIWARE (NGSI API).

After analysing the three applications standards, we developed a prototype using CitySDK principles and we realized that this facilitates and provides a clear and easy standard to reuse and improve the interchange data process through Smart City App, since it offers in a dynamic way the diverse data sources available, so when a new source is included, this can be added automatically in the application and the data interchange is quite direct and simple. Furthermore we found that with regard to the language, most of the relevant information such as category, label and description is advertised in the local language of the event's city, and so when this information is presented to the user and he or she doesn't speak the local language, the information is not completely understandable.

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CHAPTER 1

SMART CITIES

1.1. Introduction

The last report from The United Nations World Urbanization organization estimated that over 70% of the world population will be living in cities by 2050 [1]. This report also predicts that around 9.400 new cities will be built or rebuilt quickly by 2050. Over 80% of the population in Spain lives in cities already. Consequently, cities need to be prepared to face these new scenarios [2]. Smart Cities could be a strategy to manage and mitigate against the problems generated by the urban population increase and rapid urbanization.

Therefore, it will be a good starting point to have a big picture from the literature about this topic and standards to interchange data through Smart City App, as there is a drastic increase in the number of Smart City mobile apps that are built every year.

Based on the exploration of some papers there are some governments concerned about waste of funds, cause by repeated or redundant constructions in applications. Beijing for example has over 700 operation systems facing difficulties such as integration and a lack of laws, regulations and technical standards. The Beijing government also remarks that smart cities have some risks associated with technology being out of control, which could be catastrophic at a national level. [3] [2]

This research applies the systematic literature review methodology to analyse primary studies such as academic articles and scientific web pages to provide an overview of existing standards for interchanging data through Smart City Apps. Additionally, it creates a firm foundation for future research and it suggests future research in this topic.

This paper determines if a standard exists for smart cities applications and highlight how these apps are conceived. This paper also shows what data structure is used and if there is standard format for this data. Another objective of the research is to provide a prototype to show how the data is automatically transferred from one city to another and subsequently used, thanks to the standardization of the data generated by Smart City applications.

1.2. Definitions, Acronyms, and Abbreviations

Smart City (SC) - “The use of Smart Computing technologies to make the critical infrastructure components and services of a city including include city administration, education, healthcare,

public safety, real estate, transportation, and utilities more intelligent, interconnected, and efficient." [4].

Systematic Literature Review (SLR) - analyse primary studies in-depth to describe their methodology and results. The SR provides an overview of research studies that uses explicit and reproducible methods. Systematic reviews aim to synthesize existing researches.

Standard - "A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. [5]

Message Queue Telemetry Transport (MQTT) a protocol for the connection information between small devices such as sensors and actuators in Smart City systems to the Open Source community.

PAS 180 Vocabulary that defines industry-agreed understanding of Smart City terms and definitions to be used in the UK.

PAS 181 Smart City framework that provides guidelines to establishing strategies for smart cities and communities.

PAS 182 Smart City concept model that helps to establish a model for data interoperability.

PD8101 defines recommendation to the role of the planning and development process.

Business Innovation & Skills (BIS) - is a department for economic growth in the UK. It invests in education to encourage innovation and help people to start and grow a business.

Relational database (RDB) - is a database that structures data through a relational model. Data is saved in one or more tables with a unique key for each row.

Resource Description Framework (RDF) - is a metadata model created by W3C for data interchange on the Web. It is quite similar to conceptual modelling approaches, as it is built to make statements about things in the form of subject–predicate–object expressions, known as triple.

International Organization for Standardization (**ISO)** - is an independent organization, composed of 163 countries. It supports worldwide proprietary, industrial and commercial standards.

Internet Engineering Task Force (IETF) - is a global community of network operators, vendors, designers and researchers of architecture and operation of the Internet. Its mission is to help to create high quality, important technical documents that influence the way people design, use, and manage the Internet to make the Internet work well.

Constrained Application Protocol (CoAP) - is a software protocol that allows simple electronics devices such as sensors, switches and valves to communicate interactively over the Internet.

JavaScript Object Notation (JSON) - is a light data-interchange language in text format that is language independent. It is built on a subset of the JavaScript Programming Language.

JSON is based on two structures: A collection of name/value pairs and an ordered list of values.

Representational State Transfer (**REST)** - is a software architecture style and an approach to communications that is regularly used in the creation of Web services. It provides recommendations and best practices for creating scalable web services. It was developed by W3C.

Open Geospatial Consortium (OGC) - is an international organization constituted by 513 governmental agencies, research organizations and companies to develop openly interface standards. These standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT.

Hypertext Transfer Protocol **(**HTTP) - is the base data communication protocol for the World Wide Web. It is a protocol for distributed, collaborative, hypermedia applications that describes how messages are generated and transferred to Web servers and browsers.

Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) is an association within IEEE that creates worldwide standards for different areas, such as power and energy industries, information technology, telecommunication, transportation, nanotechnology, biomedical and health care and information assurance.

World Wide Web Consortium (W3C) - is an international community where different organizations collaborate to create Web standards. These standards provide an Open Web Platform to create applications that enable developers themselves to create important collaborative experiences, powered by massive data stores which are accessible on any smart device. The strength of the platform is that it supports many technologies that W3C and its partners are creating, including HTML5, CSS, SVG, WOFF, the Semantic Web stack, XML, and a variety of APIs.

1.3. Smart City

The concept of the Smart City has been explored and studied by many institutions, as it can help to mitigate against emerging problems due to the rapid urban population growth. Problems like difficulty in waste management, pollution, human health concerns, traffic congestion, lack of resources, poor infrastructures and environmental problems. Smart City efficiently combines technology, management and policy. Smart City technology provides opportunities and risks at the same time.

In existing literature many authors only take into account technological aspects of the Smart City. Innovative ideas, policies and management by institutions or organizations to improve citizens' standard of living should be considered as well. Therefore, the Smart City can be defined as the combination and use of both technologies in management and policies created and controlled by organizations, in order to allow the development of a sustainable city that meet the needs of its citizens in an efficient manner and in harmony with the environment.

The Smart City concept has become very popularly in recent years, but it is used all over the world in different situations and with different terms, the table below contains some definitions that can be found in the literature.

DEFINITION
"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens." [6]
"A city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives" [7]
A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and liability" [7]
"The use of Smart Computing technologies to make the critical infrastructure components and services of a city, which include city administration, education, healthcare, public safety, real estate, transportation, and utilities more intelligent, interconnected, and efficient." [4]
A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" [9]
A smart city could be defined as the organic integration of systems. A large organic system connecting many subsystems and components. The interrelationship between a smart city's core systems is taken into account to make the system of systems smarter. [11]
"City that monitors and integrates conditions of all of its critical infrastructures. One of core mechanisms in smart city is a self-monitoring and self-response system." [12]

Table 1 – Smart City Definition

1.3.1. Smart City's Components

Taewoo and Theresa in their research [13] identify three key factors of a Smart City to categorize the core components involve in every factor; technology (IT infrastructures and software), people (diversity, creativity and education), and institution (private and public). Additional to these we include a four component Infrastructure and services (Buildings and citizens operations)

- **Technology -** representing the use of information and communications technology (ICT). Technology performance is a fundamental component of SC. The integration between network, hardware and software technologies provides IT systems with real-time information of real world and innovative analytics, in order to help people and institutions take more precise decisions about possible actions that will optimize citizens' services and standard of living.

  IT Infrastructures of hardware and software are required, in combination with the co-operation of public institutions, schools, private sector, organizations, and citizens. Technology can be split in 6 perspectives:

- A Digital City connects communities in order to generate an environment for information interoperability, distribution, collaboration and unified experiences for all citizens. It achieves this through a broadband communications infrastructure, flexible service-oriented computing infrastructures and innovative services to meet the needs of governments, citizens and businesses.
- An Intelligent City combines society's knowledge with the digital city. An Intelligent City can be defined as a city with the infrastructure and 'info-structure' for using information technology to transform life and work in significant way. 'Intelligent city' is frequently used to describe a city that supports learning, technological development, and innovation procedures. Therefore, a Digital City is not necessarily intelligent, but all Intelligent City has digital components.
- In a Virtual City, functions are developed in cyberspace to represent real entities and people. The SC consists of its physical entities and real citizens and a parallel Virtual City consists of the virtual equivalent of real people and entities. It generates urban elements in virtual space in order to visualize them.
- The Ubiquitous city is an extension of the Digital City concept in terms of its ubiquitous infrastructure and accessibility. It creates a built environment where any citizen can get any services anywhere and anytime through any devices. It reproduces urban elements by visualizing them within the virtual space
- The Information City refers to digital environments collecting information from local communities and delivering it to the public via web portals. An Information city allows commerce, civic services, and social interactions and services between people, government institutions and businesses.

- **Human** – is about people and their relationship with others. For every SC, human infrastructure, human capital and education are crucial in urban development. This category highlights people, creative learning, education and knowledge, since these are key elements in SC to increase its human potential and help humans to lead a creative life. A city is smart when it invests in overpopulation issues promoting creativity, human capital, cooperation among relevant stakeholders and scientific approaches. Clever solutions by creative people make cities smart.

  There are 4 perspectives for this component: Creative, Learning, Humane and Knowledge

  - Creative City: Creativity is recognized as a key driver to Smart City, since smart people create and take advance from human and social infrastructure. This is about a combination of education and training, culture and arts, business and commerce and a hybrid mix of social enterprise, cultural enterprise, and economic enterprise.
  - Learning City: increases the competitiveness of urban contexts in the economy knowledge. Learning Cities are directly associated with developing expert information economy workers.
  - Humane City: apply its human potential, in order to lead creative lives. SC is a centre of higher education and better-educated individuals. The smartness of workers varies between cities.

- Knowledge City: is similar to a Learning City. The notion of a Knowledge City is compatible to a certain degree with concepts such as: educating city, intelligent city, or smart city. On the other hand, a Knowledge City is deeply connected to the knowledge economy, and its distinction is its stress on innovation.

- **Institution** – Government support is required for designing and developing Smart City initiatives. It highlights the supportive policies and the role of government, the relationship between public agencies and private parties, and their governance. To permit Smart City initiatives, this factor should include integrated and transparent governance, strategic and promotional activities, networking, and partnerships.
  Three perspectives are relevant for this factor:
  - Governance the concept highlights governance among stakeholders and institutional factors for governance. Institutional tuition and community control are crucial to the realisation of smart community initiatives.
  - Police are required to ensure the collaboration across departments and with communities to become more transparent to manage resources more effectively, and to give people access to information about decisions that impact their lives.
  - Regulations regulates the outputs of economic, societal systems and connects communities, citizens, and businesses in real time to trigger growth, innovation, and progress.

We believe that Taewoo and Theresa proposal should be taken in consideration a four factor, since Infrastructure plays an essential role in the SC development and performance.

- Infrastructure – SC will need to increase the efficiency of existing and new infrastructures and services to a level never achieved before. This will require a growth in integration of all private and public infrastructures operations and their management and operations. Buildings, roads, power supplies will require radical changes to make cities more financial and environment sustainable, since Smart Cities requires of new models more efficient and better-integrated with technology to decrease the effect of the city on the environment resource. Additionally, it is essential to encourage the effective and intelligent deployment of technology inside infrastructures.

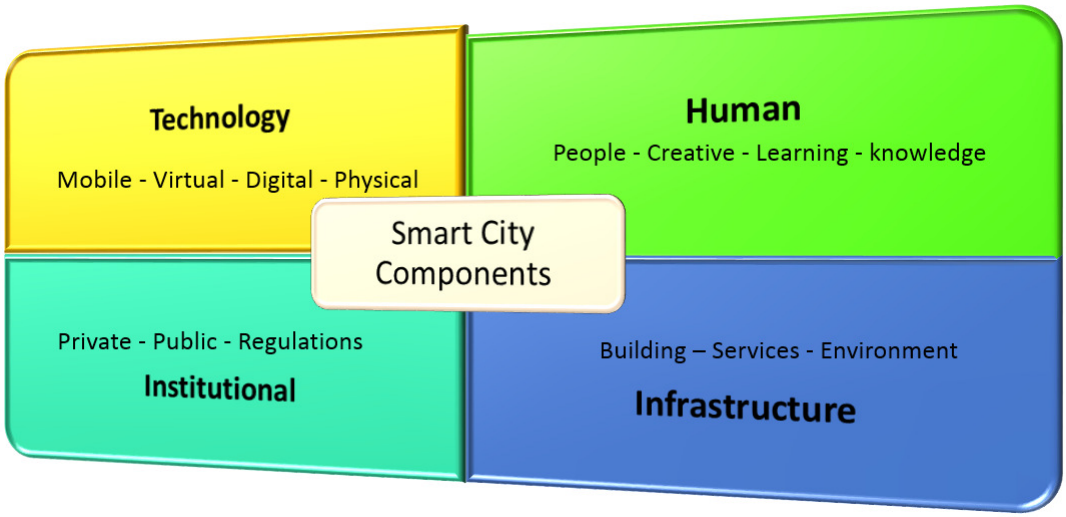

Figure 1: Smart City Components

On the other hand, Chourabi et al. [14] recognised eight critical factors of Smart City initiatives, based on the examination of an extensive array of literature. The eight clusters of factors include: management and organization, technology, governance, policy, people and communities, the economy, built infrastructure, and the natural environment.

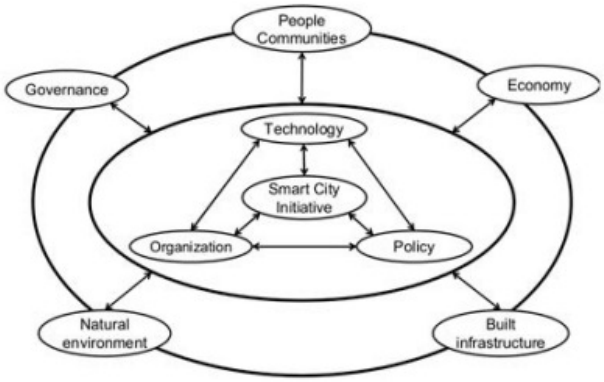

Figure 2: Smart City factors [13]

1.4. Challenges

The Smart City can provide solutions to deal with the overpopulation and urban problems cause by the increase of people living in cities, but if the Smart City is not controlled properly, other issues that may arise need to be considered.

The following challenges need to be taken in consideration to create a SC:

1. Technology can interconnect several systems and interchange data, however some considerations and policies need to be applied, since Smart City deployment impacts a great number of sectors, such as:
    - **City elements** (residential, transport, healthcare, business, education, etc.)
    - **City subsystems** (intelligent building, energy grid, healthcare systems, transport systems, security systems, financial systems, etc.)
    - **Intelligent middleware** (building automation solutions, energy grids, management databases, city surveillance and security systems, etc.)
    - **Applications** (transport governance, energy policy management, healthcare governance, remote monitoring, financial governance, etc.) [15]
2. The information is available in different formats and some problems can appear when data needs to be integrated with data from different sources. Information format and availability will allow the right decision to be taken at the right time. This digital information need be available to connect the public and private applications. Three different integration levels of information are available in every SC:

- **Open data:** governments offers their citizens and companies information, primarily through the Internet. The information is normally generic and does not adapt to different needs.
- **Valuable information:** reaching this status achieves the integrated maturity level. This information is easier to find and use, compared to open data. The (valuable) information is put in the context of citizen and company needs.
- **Ubiquitous information** the highest maturity level. The Smart City provides anytime and anywhere to all its residents, information adapted to their requirements without explicit search. Personalized information is available according to citizen profiles and is organized in open and secure platforms, so that public and private organizations can use it in order to optimize their operations or even add new innovation lines.

3. **Crowdsourcing and Collaboration** designing systems for cooperative use of large scale data relates to creating an ecosystem in which users get mutual benefit from contributing, sharing, and using data.
4. **Heterogeneity and Disparity of data** Users usually access and integrate the parts of the data they need into their own data storage, when they need it. The main challenge is that data collected by different people under different regimes and stored in different databases rarely exists in any standard formats. The disparate heterogeneous sources originate a variety of different data formats
5. **The difficult task of integrating the data** principally involves the acquisition, integration, cleaning and storage of the data.
6. **Data uncertainty and Trustworthiness** relates to the inherent levels of uncertainty of the data itself. Data might have been produced incorrectly. Some measurements might have been malevolently tampered with or intentionally supplied with erroneous information.
7. **Model and Decision Making**, users will need to subject the collected data to different forms of analysis, so the quality of the analysis, models, and decisions depends on the quality of the input data.
8. **Smart City technologies** that do not understand the role that the end user plays in capturing, delivering and generating data

1.5. Motivation

The number of devices and applications developed for Smart Cities is growing very fast to solve the big problems that cities are facing, but the lack of standards means that these applications are not 100% utilised because many of them cannot communicate with each other, thus extra cost and effort is required to allow their interoperability.

Digital technologies can collect huge amounts of data to support SC operations. Currently it is possible to gather data from sensors on buildings, roads and other elements of the city. Therefore, if this information can be shared between service delivery channels, it will help the city to improve services, monitor, re-use and control resource usage and react to real-time information.

The Department for Business Innovation & Skills (BIS) in UK has identified this problem and it has been working to address it. BIS recommends the development and application of the following standards for SC solutions: PAS 180, PAS 181, PAS 182, PD 8100 and PD 8101 [16].

Many cities are deploying relevant data in different formats through different vendors, but the capacity to share the information is limited by the use of common standards.

According with Rick Robinson [16], Executive Architect at IBM specialising in emerging technologies and Smarter Cities, the development of services and applications for Smart Cities require first, to identify what information and services are required for citizens and institutions, to help them grow and succeed. Second, to provide and specify correct platforms, tools and standards that make it easier to develop and connect applications and services.

To make the city a place of innovation, Smart City infrastructures should support Open Standards and interoperability with Open Source technologies.

1.6. Objective, research question and hypotheses

Smart City can provide solutions to deal with urban problems caused by the increase of people living in cities. On the other hand, there are some challenges in the Smart City perspective that need to be improved first. This thesis is oriented to provide some insight into Smart City standards. The thesis have two **objectives**:

1. Conducted a systematic literature review on Smart City's standards. The aim of this SLR is to identify existing standards and explore the potential of these to control the huge number of SC applications.
2. Create a Smart City mobile prototype for city events to apply standards and evaluate the benefits of them.

Research Questions:

The following three research questions are evaluated in this research:

- Does any data interchange standard between Smart Cities exist?
- If yes, what are these standards?
- Are there any for data interchange standard between Smart City apps?

Hypotheses:

The hypotheses are evaluated in this research:

- It is possible to identify interchange standards in Smart City.
- It is possible to identify interchange standards for Smart applications.

1.7. Research Methodology

The research was performed using a combination of two methodologies.

Quantitative research design was applied in this investigation. Quantitative experiments define a hypothesis to be proved or disproved. The hypothesis needs to be verifiable by mathematical and statistical means, and the foundation around which the whole experiment is designed.

Therefore, we carried out an intensive literature review, to identify the different Smart City standards. This allowed us to map the field and position the research within the context.

Then in order to further understand how standards benefit the data interchange, we developed a pilot or prototype of a Smart City app. A pilot study would allow us to test the feasibility, theories and methods on a small-scale of the larger research design. Generally, the pilot study technique refers to a smaller scale version of the experiment.

1.8. Document Structure

The thesis has been structured in 3 chapters to provide a detail overview of the research done in the Smart City topic. The description of these chapters is specified below:

- **Chapter 1: Smart City** – This provides a detail explanation of the topic research done for the MIRI master. It presents the Smart City definition, components and challenges. Additionally it contains the three Research Question details.

- **Chapter 2: Systematic Literature Review -** describes a systematic literature review conducted to study the existing standards available to allow the interoperability between Smart City applications. It presents a brief introduction to Systematic Literature studies, which describes the protocol followed for this SLR. This shows the results of the SLR.

- **Chapter 3: Event Everywhere Prototype –** this chapter provide a detail view of how the mobile application was developed for this research. The project plan, mobile application specifications, design and the application implementation are described in this section.

  Appendix – provides additional information about data sources structures uses for the prototype.

CHAPTER 2

SYSTEMATIC LITERATURE REVIEW

This chapter detects and assesses the different standards for Smart City application in the literature. This study has been developed according to the SLR methodology, following the process within the software engineering area [17]. The SLR process can be separated in several activities, which can be grouped into three phases: planning; conducting the review; and reporting the review.

2. Systematic Literature Review

The systematic mapping of studies is a methodology used frequently in medical research. It has been adapted for use in the IT area. It attempts to gather all research related to a specific topic in order to obtain an overall view of the research information available in for this topic.

2.1. Concepts

Primary research or study consists of a group of original primary data collected by the researcher. It can be accomplished through various methods, including questionnaires and telephone interviews in market research, or experiments and direct observations in the physical sciences, amongst others.

Secondary research involves the summary, collation and/or synthesis of existing research rather than, where data is collected from primary researches, for example, research subjects or experiments.

A systematic literature review have been done to gather and analyse the different standards by defining and conducting a rigorous protocol following the guidelines described by Pearl [17]. As a consequence of this research, we have been able to evaluate the current state of the art in SC standards and identify the strengths and weaknesses of its current status.

Systematic Literature review is a procedure that analyses primary studies in-depth to describe their methodology and results. The SLR provides an overview of research studies that uses explicit and reproducible methods. Systematic reviews aim to synthesize existing researches. The SLR characteristics are:

- Fairly (without preferences)
- Rigorously (according to a defined procedure)
- Openly (ensuring that the review procedure is visible to other researchers)
- Create a firm foundation for future research

We have executed a SLR to be able to rigorously and systematically locate, assess and aggregate the outcomes from all relevant empirical studies related to Smart City and standard topic, in order to provide an objective summary of the relevant evidence that can be found in scientific sources.

The evidence-based paradigm advocates the objective evaluation and synthesis of empirical results of relevance to the research question through a process of systematic literature review and the integration of that evidence into professional practice.

In this research a Systematic Literature Review was conducted in a precise and unbiased way. A rigorous and clear methodology was used. The process and guidelines used in this research are defined by Pearl [17].

2.2. SLR Process

- ✓ **Planning the review -** In this phase the definition and description of the protocols need to be specified to determinate the criteria that will be used to complete the review and definition of research question, search keywords, search databases and selection criteria for relevant papers.
- ✓ **Conducting the review -** Once the protocol and guidelines has been defined, the review phase can be executed. This phase contains five steps to execute the review. These steps consist of the identification of research, selection of primary studies, study quality assessment, data extraction and data synthesis.
- ✓ **Reporting the review -** The final phase includes writing up the results of the review and sharing the results to interested members. It contains the specifying dissemination mechanisms, formatting the main report and evaluating the reports.

Systematic review contains some discrete actions, which can be grouped into three main phases: planning, conducting the review and reporting the review. The image below shows the general 10-stage for the review process.

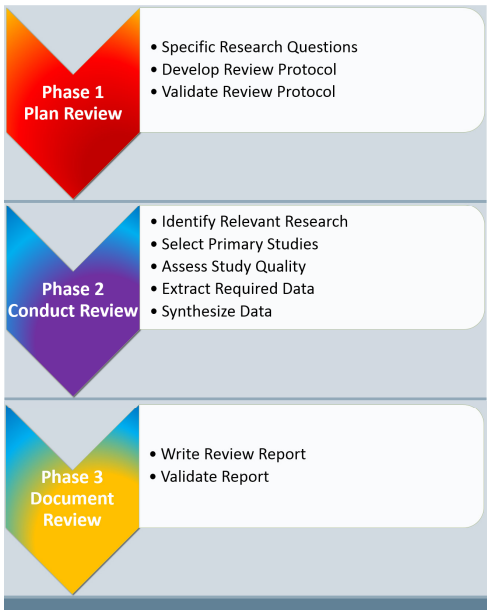

Figure 3: SLR process

The paper aggregates empirical evidence which has been obtained using a protocol. The protocol minimizes bias in the study by identifying in advance how the systematic review needs to be carried out. The protocol defined the plan for the review and search, specifying the process to be used, any conditions to apply to select primary studies, any boundary conditions, quality, measures and who will be in charge of each task.

The protocol was reviewed and validated by each researcher separately and then together. A pilot run of the data extraction process was executed in one of the sources. The results of this were not however considered satisfactory by the reviewer, so the search string and the exclusion criteria was modified slightly for conducting the data extraction again.

2.2.1. SLR Planning the Review Phase

Cities need to contend with extra costs and extra efforts to allow the interoperability between them to have all the information required to take the right decisions. Currently, digital technologies can collect enormous amounts of data to support SC operations.

Many private and public institutions are deploying important data in different formats, so in this research we try to understand how this information needs to be deployed to get the best benefit at the lowest cost for citizens.

Research in this topic has been conducted to confirm that a systematic review in this area is necessary. A search and review of any existing systematic reviews of the topic of interest has been performed. This has been split in two steps:

1. A manual searched of any systematic literature study and other type of review and state of the art documents in ACM data source about this topic.
2. Then, an automatic search to the ACM database was executed, using the same keywords defined in the Pilot different combinations of the search terms section with the following terms: SLR, systematic review, state of the art, and systematic mapping. As a result, in the automatic search we found two papers fulfilling the search criteria. However, after checking them, we found that neither of them presented a review on Smart City's standards. As a result, after executing the exploration, it can be affirm that there is no literature study on standards for Smart Cities.

2.2.1.1. Research Questions:

Specifying the research questions was the most important part of this systematic review, as the research questions informs the whole systematic review methodology:

The search process identified primary studies that address the research questions, for extracting the data items needed to answer the questions. Then, the data analysis was synthesised in such a way that the questions was answered.

Questions 1:

Does exist any data interchange standard between Smart Cities?

Questions 2:

If yes, what are these standards?

Questions 3:

Is there any data interchange standard between Smart City apps?

2.2.1.2. Review Protocol:

The review protocol identifies the methods that will be used to carry out a specific systematic review. A protocol is necessary to reduce the possibility of researcher preference. The review protocol consists of seven steps. These sections show how relevant research was identified and selected to primary studies and which data was extracted.

The elements of a protocol include:

- ✓ The strategy that will be used to search for primary studies including search terms and scientific data sources to be searched.
- ✓ Study selection criteria are used to determine which studies are included in, or excluded from, a systematic review.
- ✓ Study selection procedures describe how the selection criteria will be applied.
- ✓ Study quality assessment checklists and procedures define quality checklists to assess the individual studies.

- ✓ Data extraction strategy to define how the information required from each primary study will be obtained.
- ✓ Synthesis of the extracted data.
- ✓ Distribution strategy of the information.

The search strings applied in the different data sources were constructed using the following steps:

2.2.1.3. Determinate key works based on the research question and the topics of this study:

- Data
- Interchange standard(s)
- Standard(s)
- Smart City/cities
- Application(s)
- Pattern

2.2.1.4. Identify and include synonyms of the related terms:

- Exchange standard(s)
- Interoperability
- Pattern(s)
- App(s)
- Protocol(s)
- Tool(s)
- Data analysis
- Data management
- and alternative spelling for major terms

2.2.1.5. Search for keywords used in relevant document in the field of researches:

- Smart City/Cities
- Intelligent cities
- Smart City application
- Mobile applications
- Software architecture
- Open systems
- Data structure

2.2.1.6. Check keywords from relevant papers researches and initial searches on the relevant databases

- IEEExplore
- ACM DL
- Scopus
- Web of Science

2.2.1.7. Classify the words that belong to the same category using OR relationships:

- Smart city OR intelligent city
- Applications OR mobile applications OR software systems OR open systems OR software architecture
- Data OR data management OR data analysis OR data structure
- Standard OR format or protocol OR pattern OR interoperability

2.2.1.8. Link main terms using “and”

[Smart city OR intelligent city] AND [Applications OR mobile applications OR software systems OR open systems OR software architecture] AND [Data OR data management OR data analysis OR data structure] AND [Standard OR format or protocol OR pattern OR interoperability]

2.2.1.9. Pilot different combinations of the search terms

Four data sources were used to search primary studies for our research: IEEExplore, ACM DL, Scopus and Web of science.

Five search strings were generated. The final string was selected because we found more documents using this one:

- ✓ (("small city" OR "intelligent city") OR "smart cities") AND (applications OR app) AND ("data management" OR interoperability) AND (standard OR format OR pattern)
- ✓ (("Smart city" OR "Smart cities") AND data AND management AND app)
- ✓ (("Smart city" OR "Smart cities") AND "interoperability")
- ✓ (("Smart city" OR "Smart cities") AND "interoperability" AND (app OR application))
- ✓ ("smart city" OR "intelligent city" OR "smart cities" OR "intelligent cities") AND (applications OR app) AND ("data management" OR interoperability OR ontology)

The final Search String was executed across all data sources to get the primary studies, then to filter them and get the relevant ones for the research two criteria were decided:

- Filter primary sources solely from archival journals and proceedings.

- Remove papers that are not available
- Select the ones that contain the words 'Smart City'.

2.2.1.10. Validate Protocol:

The validation of the protocol is a critical part of a systematic review. A procedure was agreed for evaluating the protocol. The Master thesis' tutor reviewed the protocol and the final report. The protocol was corroborated by querying the selected databases and analysing at a sample of the results. It was agree that the queries would lead to significant results that could answer the research questions.

Moreover, the consistency of the protocol can be reviewed to confirm that:

- ✓ The search strings are correctly derived from the research questions.
- ✓ The data to be extracted will properly address the research questions.
- ✓ The data analysis process is apt to answer the research questions.

2.2.2. SLR – Conduct Review Phase

After the protocol has been decided, the review phase starts. In this phase the relevant data is extracted from selected scientific data sources using the following steps:

- ✓ Identify Relevant Research
- ✓ Select Primary Studies
- ✓ Assess Study Quality
- ✓ Extract Required Data
- ✓ Synthesize Data

2.2.2.1. Identify Relevant Research

The goal of this step is to find as many primary studies relating to the research question as possible through an impartial search strategy. All databases selected need to be queried to obtain the studies.

Initial searches for primary studies were conducted using digital libraries but this is not sufficient for a full systematic review. Other sources of evidence were also searched manually as:

- ✓ Reference lists from relevant primary studies and review articles
- ✓ Journals, grey literature and conference proceedings

2.2.2.2. Select Primary Studies

After obtaining the potential relevant primary studies, these studies must be assessed to determine their relevance. Selection criteria were proposed to detect those primary studies that

offer direct evidence about the research questions. The following selection criteria were applied in order to filter the studies:

- ✓ Selection by title – remove noise from the results.
- ✓ Selection by abstract - The primary studies that were related to this topic, but did not present a contribution were discarded.
- ✓ Selection by full paper through fast reading - we removed the papers which did not present any standards or protocols for Smart City.

2.2.2.3. Assess Study Quality

An initial issue faced was that there is no agreed definition of study "quality". However, we verify that the papers produce results that depart systematically from impartial researches.

2.2.2.4. Extract Required Data

For all primary studies, the qualitative results were extracted. This was based on the abstracts, on the conclusions and partly based on the full text. We progressed between reading primary papers, data extraction and interpretation in several cycles. Data extraction in qualitative synthesis shares with primary qualitative research the importance of submersing in the data.

2.2.2.5. Synthesize Data

The data extracted from the primary papers was synthesized by classifying the papers results and comparing them against each other. Classifications were defined based on different layers of Smart City standards. Data synthesis involved organising and summarising the results of the included primary studies.

2.2.3. SLR – Document Review Phase

This is the final phase of a SLR, which consists of writing up the outcomes of the analysis and sharing the results to other involved participants. This section tries to communicate the outcomes of a SLR effectively.

2.2.3.1. Document Review

The review was executed following the criteria and protocols defined in the previous two phases.

Four scientific data sources were used to find the different primary research papers for this SLR process. The search was done on 10th December 2014, where 107 paper were found and reviewed for this study. 102 were found from automatic search and 5 from a manual search of the Internet.

- Scopus – Retrieves 48 papers, of which 20 were relevant for this topic. 7 of these were discarded after a fast reading. So 13 research papers were analyzed in depth.
- IEEEXplore – Showed 25 papers, of which 6 were already in Scopus and only 3 of them were relevant for this topic, but after a fast reading only two of them were considered for this research.
- ACM – Displayed 21 primary studies, but 5 of them were found in the Scopus or IEEEXplore sources and only 5 of them were relevant for this topic. After a fast reading, only 1 was taken forward for this SLR.
- Web of Science – Provides 8 papers, of which 7 were in Scopus, IEEEXplore or ACM data sources. The remaining paper was analysed and rejected as not being relevant to this investigation.
- Manual – Many documents were found via the manual research, but only 5 of them were taken in account for this process.

Therefore 107 primary research papers were found, of which 18 were repeated, 33 were relevant for the SLR process. After a fast reading of these documents 12 of them were discarded, so a total of 21 primary studies were analysed in detail to answer the research questions. In the following figure and table this information have been summarized.

	Found	Repeated	Relevant	Remove after fast reading	Papers Analysed
Found Papers Scopus	48	0	20	7	13
Found Papers IEEExplore	25	6	3	1	2
Found Papers ACM	21	5	5	4	1
Found Papers Web of Science	8	7	0	0	0
Manual	5	0	5	0	5
Total	107	18	33	12	21

Table 2 – SLR search results

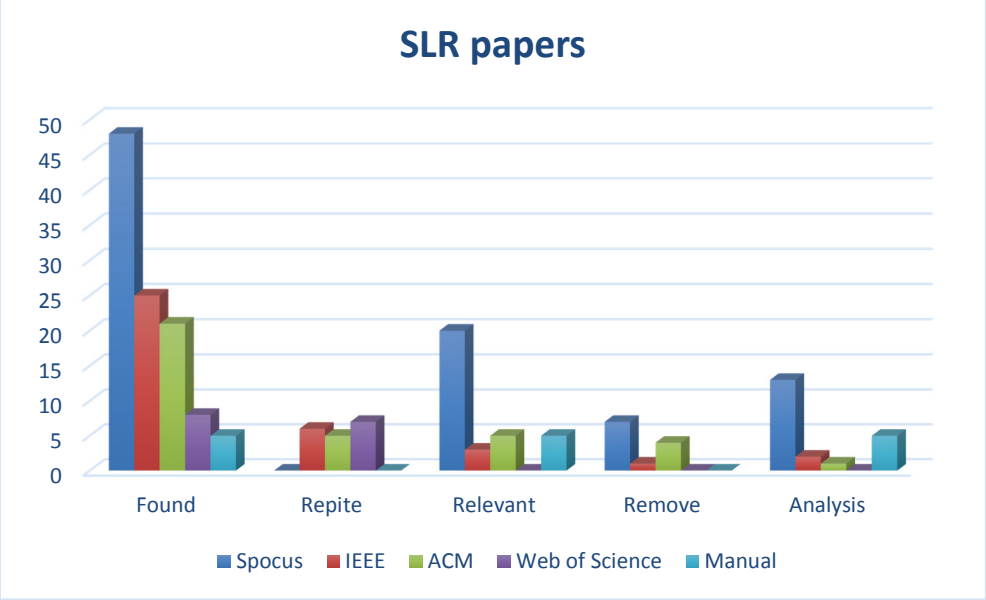

Figure 4 - SLR search results

Smart City standards has become an important research topic from 2010 until 2014. It has been registered in an incredible number of papers in 2013 and 2014. During 2010, only 2 papers were published, but in 2014, 33 papers were distributed. This means that around 16 times more paper were published in only 3 years. This increase can be easier appreciated in the table and graph below.

	2010	2011	2012	2013	2014	2015
Spocus	1	3	5	21	17	1
IEEExplore	1	0	1	4	5	0
ACM	0	2	1	4	9	0
Web Service	0	0	0	0	1	0
Manual	0	0	1	1	0	2
Total	2	5	8	30	33	3

Table 3 – Search results per year

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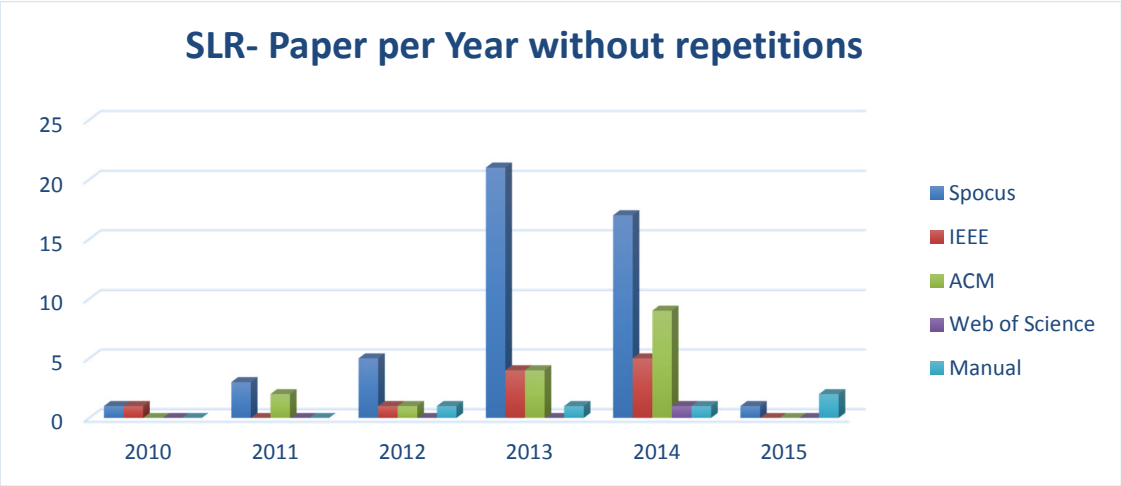

Figure 5 – Search results per year

Therefore we analysis the three research questions on the centre of this information.

After analysing all the studies we can conclude that 21 of the 107 studies found initially, present standards or protocols related to the interchange of data for SC

Source Data Base	Papers
Scopus	[18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30]
IEEExplore	[31], [32], [33]
ACM	[34]
Manual	[16], [35], [36], [37], [38]

Table 4 – Search references

2.2.3.2. RQ1 – Does any data interchange standard between Smart Cities exist?

The 21 primary studies were reviewed and analysed individually to consolidate and compare the information therein. 13 different standards were mentioned in the analysed studies. These standards are applicable in different levels of areas of Smart City. The standards have been classify according to four levels of abstraction, which range from devices to business logic required and used by the Smart City Apps. These are the following levels:

- **Smart Devices** – This level represents the different standards required by sensors, mobile, computer and other devices to generate and transmit information relevant to take decisions for Smart Cities. Generally these devices are connected to other devices or networks via different protocols such as: IEEE 1451, MQTT and etc.

- **Data** – At this level we group the different standards applied for formatting and structuring the data collected from the previous level. The standards in this level facilitate data collection, storage and merging through different schemas for instance: RDF, XML, CKAN and etc.
- **Services** – This level contains the standards to specify the best way to manipulate and use the structured data that was produced in the Data level through services. The services can generate new data, validate information, provide simple analytical services, etc. Among the best known standards at this level are Web Services, HTTP and JSON.
- **Applications** – The standards classified in this level provide guidelines to design, build, deploy and exploit services than use and share public information. The different applications available for customer and institutions visualise and use information through smartphones, tablets, desktop and laptop computers. Therefore some standards try to encourage the interoperability of these apps such as iCity, CitySDK and FIWARE standards.

Standards are structured in the four levels classification, according to the main functionalities of the smart city system that can be visualized in the image below.

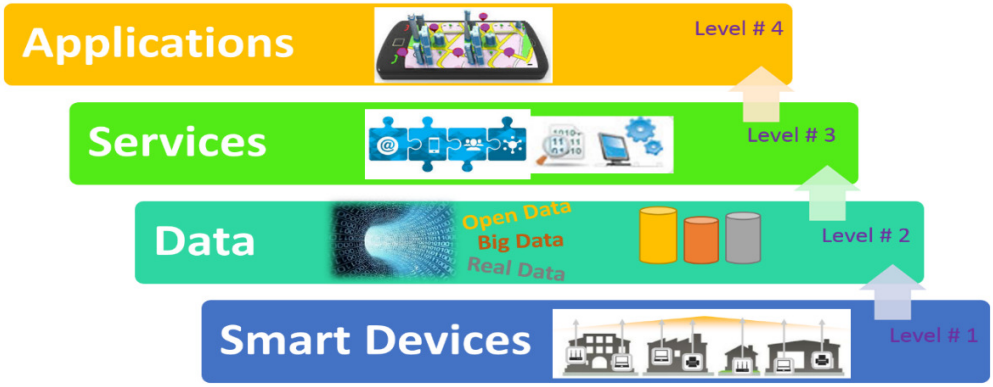

Figure 6: Smart City Standards Levels

Following the classification previously defined, we have catalogued the standards found in the primary studies in the next table.

Standards/ Protocols	Level
CitySDK	4
CKAN	2
HTTP	3
iCity	4
IEEE 1451	1
IETF CoaP	3
JSON	3
FIWARE	4

MQTT	1
PAS	2
RDF	2
Restful	3
Web Service	3

Table 5 – Standards classification

2.2.3.3. RQ2 – If yes, what are these standards?

As we can see in the tables, the most popular standards are Web Services and RDF with 13 and 10 appearances respectively. PAS, iCiy and MQTT standards are the least popular

In this question we aim at identifying the different standards for Smart Cities. Additionally we define each of them and also how they were applied in the primary studies. The different standards found in the literature are listed in the following tables. Each table presents the number of studies that mentioned them for each data source

Standards/ Protocols	# of appearances
CitySDK	2
CKAN	4
HTTP	6
iCity	1
IEEE 1451	5
IETF CoaP	4
JSON	4
FIWARE	2
MQTT	1
PAS	1
RDF	10
Restful	5
Web Service	13

Table 6 – Standards

As we can see in the tables, the most popular standards are Web Services and RDF with 13 and 10 entries respectively, between the least common we can listed PAS, MQTT and iCity standards. We need to remember that some of these standards are quite new, therefore time is required to adopt and apply them. In order to provide accurate and significant results, the definition of each standard or protocol is specific below:

- ✓ **CitySDK** help cities to expose useful information to developers in a simple way. It has been used by some cities to test a common API standard for mobility, tourism and civic participation apps. Currently, Lisbon, Lamia, Rome, Helsinki, and Amsterdam have joined the project.

  The data model is planned to be utilised across other 31 cities in Europe. The idea is that cities will create adaptors between their current data sets using the CitySDK data models so that an NGSI API can access equivalent data on entities in each city.

  CitySDK provides open and interoperable processes, service interfaces, guidelines and usability standards. Therefore, it works like an app store which simplifies the transmission of Smart City applications from one city to another city. In other words, it allows an efficient use of the knowledge for developer groups to be applied in city service creation.

- ✓ **CKAN** - is an effective system and repository for data management that makes data available.

  The CKAN platform has been used by numerous governments, organisations and communities around the world to share public data.

- ✓ **FIWARE** – is a platform developed as part of the Future Internet initiative launched by the European Commission in collaboration with the ICT. The agreement is to use the NGSI API as the open standard for how cities must gain access to contextual information in real-time.

- ✓ **HTTP** protocol has been used to enable continuous direct access and connectivity for the semantic sensor services. It has been applied to support communications between sensor services and existing high-level Web service.

- ✓ **iCity** is a European project that started in 2014 and defines a standard and secure platform to access to city public information systems to generate new services. It allows data to be read and interaction with opened information systems. This platform links directly with the IT opened information systems of Genova, Bologna, London or Barcelona cities.

  The different information systems providers can control any request or the access of any current user in a controlled and structured manner. This platform offers the most secure software of the market. It is very flexible because it accepts any technology.

  The iCity standard and platform encourages the development and deployment of open services for urban benefit and founded the use of available public and digital city information. This represents a change in the governance of cities and the concept upon which traditional public service delivery has been based. The concept of Open Data provides a wide access into the public data to maximize the number of services in public sector.

- ✓ **IETF CoaP** - Internet Engineering Task Force Constrained Application Protocol: is a specialized web transfer protocol for use with controlled nodes and controlled networks. The nodes often have small amounts of ROM and RAM, while networks like as IPv6 over Low-Power Wireless Personal Area Networks frequently have high packet error rates. The protocol is designed for machine-to-machine (M2M) applications such as smart energy and building automation.

  CoAP offers a request/response interaction model across application endpoints. It supports built-in discovery of services and resources, and includes key concepts of the Web such as URIs and Internet media types.

  This protocol was used to provide support for enabling intelligent services between sensors and allows total communication among sensors.

- ✓ **IEEE 1451** - standard was used as an interface for smart transducers, which defines on-board electronic datasheets for hardware capabilities discovery. This standard contains open and network-independent communication interfaces for linking transducers to systems, microprocessors and control/field networks.

- ✓ **JSON** - JavaScript Object Notation is a text and lightweight data interchange format, which is language independent.

  JSON has been used for its interoperability across all resources and in order to build the interfaces with the client applications and users through enterprise communications interfaces. Information can be sent in JSON format between nodes.

- ✓ **MQTT** – Message Queue Telemetry Transport is a protocol created and donated by IBM. It is a "light weight" messaging protocol to be used over of the TCP/IP protocol. It is designed for connections with remote locations where limiting code is mandatory and/or network bandwidth is restricted.

  This protocol was used in the primary studies to allow the connection between small devices such as sensors and actuators in Smart City systems to the Open Source community.

- ✓ **PAS** - To improve and solve the problems for a city to become a Smart City, The Smart City Advisory Group recommended the use of the next standards:

  - PAS 180 – vocabulary to facilitate the communication and understanding of Smart City terms and definitions by providing a common language for developers, designers, manufacturers and clients in the UK.

- PAS 181 – provides a framework for city leaders to improve, approve and deliver Smart City strategies that support and transform city's' abilities to meet their upcoming challenges. This framework provides a set of reliable and repeatable patterns that city leaders can use to support develop and deliver on Smart City strategies.

- PAS 182 – specifies a data model to allow the interoperability of systems and data transmission between different institutions. The standard creates a framework for Smart Cities that allows information sharing across organizations and people at multiple levels, the derivation of data and the observation of decisions in operational data.

✓ **RDF** – It is a standard model for data exchange on the Web. RDF simplifies data merging even if the original schemas differ. Its principle feature is the capacity to allow the development of schemas over time without needing to change all the data.

RDF extends the linking structure of the Web to use URIs to define the relationship between elements.

RDF was applied in the research to the conversion of complex, non-structured data into a structured RDF format, which is simpler to analyse, retrieve, convert and publish

✓ **REST/ Web Service -** these guidelines have been used to expose and make data accessible through REST web service.

If all cities were to use the same NGSI data model, it would allow the creation of scalable models and the opening up of data collected from sensors and other smart technologies. This would make it available in a standard way for third application developers.

If this standard API were available to every city, it would permit developers to build an application once and use it in several cities.

2.2.3.4. RQ3 – Is there any data interchange standard between Smart City apps?

After reviewing and analysing the information in the research, we concluded that some standards have been used to deal with the data interoperability issues in SC. These standards have been applied at different levels:

Smart Devices – Most of the standards registered in the literature are oriented to the communication with sensor and other smart devices. Among the standards used at this level we can mention: W3C, OGC, HTTP, IETC, IEEE and MQTT.

Data – With regard to the data interchange, we found some standards associated with the different structures and types of data require in SC. On the one hand, the research applies some standards such as: RDF, XML, PAS 182, CKAN and ISO, but on the other hand, the solution most

applied to these issues where the use of Ontologies. These allow the management of unstructured and structure data in a robust and reliable way.

Services – For this level we found the applications of Rest, HTTP and Web Service standards. These standards allow the exposure and reuse of components to other services. They also makes it easy to deploy and use legacy code.

Applications – There are less standards in this level than in the other levels. CitySDK, iCity and FIWARE (NGSI API) standards were created to open up data generated or collected from different organizations or smart devices and to make it available in a uniform way to third-party applications or other SC applications.

So, we can confirm that we found three interchange standards between Smart City apps: CitySDK, iCity and FIWARE (NGSI API)

2.3. SLR – Conclusion

- ✓ We found 13 different standards in the 21 primary studies analysed.
- ✓ The most popular standards are Web Services and RDF with 13 and 10 entries respectively. PAS, iCity and MQTT standards are the least popular for Smart City area.
- ✓ In the applications level we found the following standards: CitySDK, iCity and FIWARE (NGSI API).
- ✓ The most popular solution to deal with the data interoperability challenges mentioned in the different studies analysed for this SLR is ontologies. They are applied as a mediator for distinct schemas of individual data sources. Additionally ontologies allow the unification and mapping of data coming from several sources and with different types such as static and dynamic.
- ✓ Middleware is the second most common solution propose in the primary studies to deal with the semantic challenges introduced by the data heterogeneity and the non-existence of a common model.

CHAPTER 3

EVENT EVERYWHERE PROTOTYPE

3. Prototype Specification

The Event EveryWhere prototype is a small mobile application built to test and evaluate how we can apply the existing standards for Smart City applications and highlight how these standards can be used for automatically transferring and subsequently using data, from one city to another city.

3.1. Prototype Standard

CitySDK, iCity and FIWARE standards were found in the literature for allow interchange data at the application level. We have analysis the 3 standards and we decided to use only CitySDK in the prototype for the following reason:

- ✓ FIWARE standards provide access to real-time, contextual information. The context information is about all entities that define the city and what is going on and the values that characterize those entities that change very quickly such as bus location or traffic. In our case the data is updated monthly, so this standard is not required.
- ✓ iCity defines a standard and secure platform to access city public information systems, in order to generate new services. It allows the reading of data and interaction with opened information systems. This platform offers event information for Barcelona, Cornella and Lamia(coming soon) cities, but each city presents this information through different formats. Therefore, additional work would be required to join all this data.
- ✓ CitySDK provides event information for the following cities: Lisboan, Helsinki, Amsterdam, Roma and Lamia. The event details is structured with **W3C-POI WG** XML syntax. The CitySDK project identifies a common set of APIs, so cities can create adaptors between their current data sets using the CitySDK data models. Therefore several cities' data with an equivalent format can be accessed in a simple way.

In conclusion, CitySDK permits the use of data from different cities through the same format without requiring extra effort to unify the event data.

3.2. Prototype Development plan

This prototype was developed using the **Agile Model**. The Agile development model is a type of Incremental model. In this methodology the software is developed in fast, incremental cycles. This results in small incremental deliveries with each release building on earlier functionality. Each delivery is tested and reviewed to certify software quality.

We have decided to use this methodology for the following reasons:

- It allows the continuous delivery of small pieces of functional software.

- Working software is delivered frequently. In our case every 3 weeks.
- It encourages direct conversation between the team, which in this project was only two people; the advisor and myself.
- Continuous care is given to good technical design.
- It is ideal when regular changes are required.
- Late modifications in requirements are permitted.
- It is used for time critical applications.
- It is easier to develop, test and debug, since it covers small pieces of software for each iteration.
- It permits more liberty of time and decisions, so we can delay critical decisions until more or better data is available. In other words, the project can move forward without fear of reaching an unexpected stop.

3.3. Agile Model steps

This model contains six principle steps.

Plan: during the planning step we identified the objective, scope, and feasibility of the master project, to ensure that this research can both be completed in one semester and add value to the Smart City topic. We identified and analysed previous studies and solutions to use them as starting point for this project. During this phase we conducted a systematic literature review to assess the existing standards for Smart City application. Additionally we reviewed the existing available technologies to create the prototype and test the standards.

Spring Design: Define the work and effort to complete for the iteration, identify the level of the complexity and risk in the iteration and any mitigation against the possible problems and the propose solutions to them. Design the technical solution that will be applied during the interaction and determine how this will be joined with the existing code. Additionally, we compare project status and progress to the actual plan, as assets perform the scheduled work. During this phase, project plan may need to modify schedules and do what is necessary to preserve the project on track.

Development: all that will be essential to implement the project is organized. This phase consists of building against the project requirements that where defined previously.

Test: Review and check the software functionality that was developed in previous phase. Asses the code execution, so problems can be recognised early and corrective action can be taken, when it is required, to control the execution of the project.

Demo: Test and show the application functionality with the different users. In our project the advisor is playing the role of user of the application.

Deployment: In this step the application is installed in production environment. The software must operate according to the requirements.

3.3.1. Agile Model Cycles

For this project 3 cycles were executed to complete the prototype.

- **Cycle 1:** In this cycle we have developed the mobile application framework that shows the Barcelona and other international city events. Cycle Period: 27/04/ 2015 – 17/05/2015.
- **Cycle 2:** Extract, Transform and Load the city events from different sources. Cycle Period: 18/05/ 2015 – 07/06/2015.
- **Cycle 3:** Shows the events retrieved during the previous cycle in the mobile application framework built in cycle 1. Cycle Period: 08/06/ 2015 – 28/06/2015.

We have adopted a document continuously approach. In other words, the documentation has been made throughout the life-cycle, in parallel to the creation of the application solution.

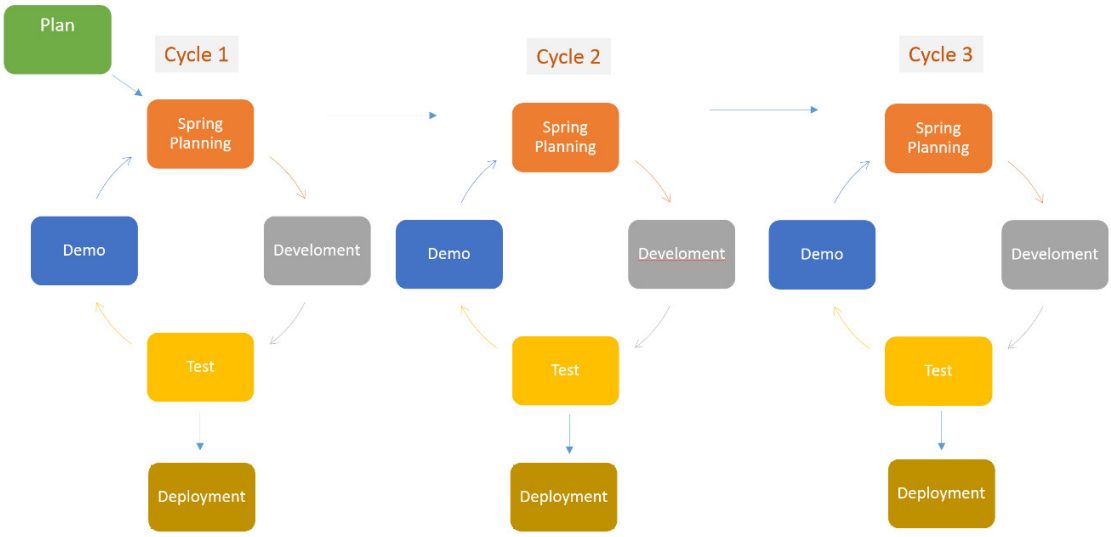

Figure 7: Agile Model Methodology

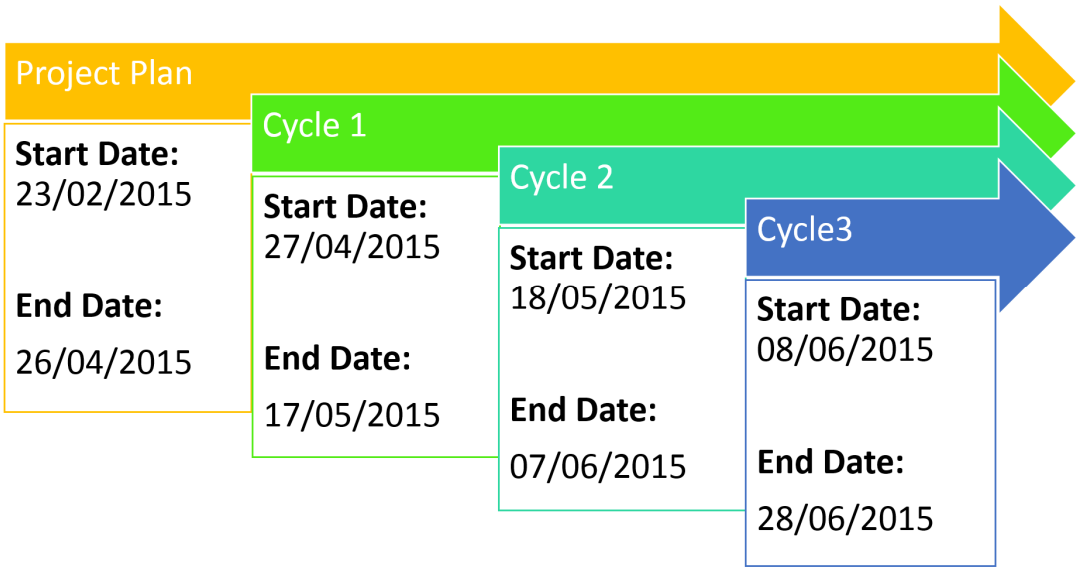

Figure 8: Agile Model cycles

3.4. Prototype Specification

Event Everywhere is a mobile application created to analysis and evaluate in what way we can use the Smart Cities' standards for applications and understand in what manner these standards can be applied to automatically transferring and using data between different cities, without requiring another mobile application. In other words, if we have a mobile application to visualize the Barcelona city events and we travel to another city such as: Lisbon, Amsterdam or Helsinki, we want to allow the user to see these cities events reusing their current mobile app without needing to download and install another application per city. Additionally, this prototype shows what data structure is used and the standard format for this data.

This prototype is designed to test and try the Smart City standards to interchange data between different applications. Prototyping specifies a real case rather than a theoretical one. Additionally, this prototype will help us to evaluate the standards benefits and status for Smart City applications.

3.5. Use Case Diagram

The following use case diagram identifies the limits between the users and the mobile application. This diagram allows the inspection of each business use case and helps determine, in conjunction with the stakeholders, which part of the business use case should be satisfied by some sort of functionality. This diagram take into account the abilities of the actors, the constraints and the goals of the project.

The use case diagram shows the actors/users outside the application. The service use cases (SUCs) are the ellipses inside the rectangle. The lines denote usage. Note that actors can be either automated or human.

The following use case diagram displays a summarizing of the next SUCs:

- Login
- Logout
- View current city events
- View international city events
- Add event to calendar
- View events in map
- Get list of events per city

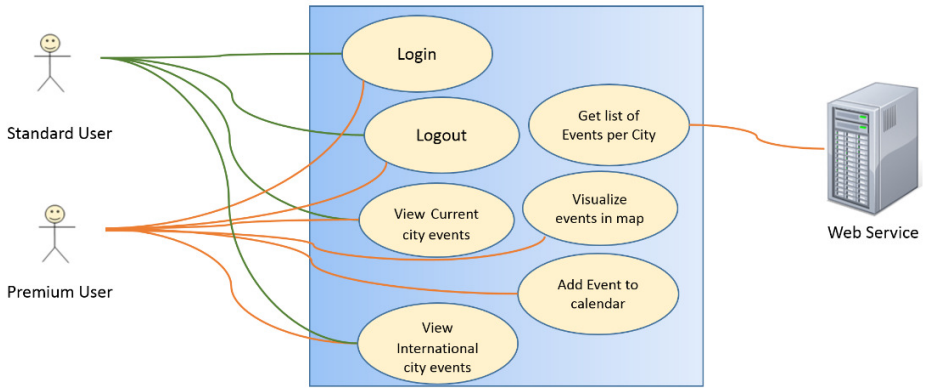

Figure 9: Use Case Diagram

For this prototype it will be implemented the use cases associated with the standard user.

3.5.1. Use Cases

Use Case 1	View current city events
Objective	Allow users to see a list of the events for their current city
Priority:	High
Trigger:	A Barcelona citizen has some free time and wants to check the coming events in the city to go out.
Actors:	Any person with mobile phone or tablet that have downloaded the application and installed it.

Preconditions:	User is logged in the application
Post conditions	A list of events must be displayed with the following details: • Event name. • Start Date • End Date • Location • Description • Image • Location
Flow Events - Basic Flow	A. Basic Flow 1. User click the access into the Event EveryWhere icon through their device. 2. User go to the menu in the app. 3. User click in Current City Events link 4. A new screen appears with the list of events of Barcelona City.

Table 7 – Use Case 1

Use Case 2	View international city events
Objective	Allow user to see a list of the events for their current city
Priority:	High
Trigger:	A Barcelona citizen is planning to travel to Lisbon next weekend and wants to check the coming events in the city in order to go out.
Actors:	Any person with mobile phone or tablet who has downloaded and installed the application.
Preconditions:	User is logged in the application
Post conditions	A list of events must be displayed with the following details: • Event name. • Start Date • End Date • Location • Description • Image • Location
Flow Events - Basic Flow	A. Basic Flow 1. User click the access into the Event EveryWhere icon through their device.

	2. User go to the menu in the app. 3. User click in International Events link 4. User click in Lisbon city Events link 5. A new screen will appears with the list of events of Lisbon city.

Table 8 – Use Case 2

3.6. City Events – Data Sources

For the prototype two different data sources were used, as we wanted to analysis how standards can improve and facilitate the use and transfer of data with different formats and providers. The sources were:

- **Open Data BCN Portal**

Barcelona City Council makes public all government data without any legal restriction. This information is available to everybody in open, digital formats standard, which is structured and understandable. Open Data BCN portal simplifies access to this data and encourages their use. [39]

All public, businesses and private institutions have access to this data easily, since this portal allows discovery of data that allows the creation of new services, which generate social and commercial value.

This City Council initiative increases transparency of government institutions through the publication of data relevant to all parts of society. Citizens, businesses and institutions analyse civilization's data needs and the reuse of public data is encouraged.

With regard to events data, this portal offers two versions of the Barcelona events. One contains the daily events and another collects the cultural and leisure events per month in XML format.

- **CitySDK**

CitySDK is “a service development kit” for cities and developers that aims at harmonizing application programming interfaces (APIs) across cities. “ [40].

This project have developed 3 different APIs: Smart Participation, Smart Mobility and Smart Tourism. For this project we will take in consideration only the Tourism one, since it contains city events details.

The Smart Tourism creates location-based mobile services for tourists. These services allow the building of a European market for tourism applications founded on Open Data publish by public and private institutions.

The Tourism services provide information in 4 areas: Points of Interest, Events, Itineraries and Categories/Tags. For this project we have focused only on event information.

3.7. Prototype Design

A mobile app is a computer program designed to run on smartphones, tablet computers and other mobile devices.

These Apps started appearing in 2008 and are typically operated by the owner of the mobile operating system, such as Google Play, Windows Phone Store, Apple App Store, and BlackBerry App World. These apps are free or paid. Usually, they are downloaded from the platform to a target device.

In this section we have analysed the mobile platforms, the development strategy, the data integration and the application architecture that we applied for this prototype.

3.7.1. Mobile Platform

A summary review of the most common mobile devices operating systems (OSs) is provided in this section. There are more than 10 different OS available for mobile app, so most developers need to face significant diversity in mobile technologies for smart devices.

Each platform or OS needs specific skills in order to develop and deploy for it proficiently, since each has its own way of doing things and its peculiarities. Therefore, to support more than one aspect of the platform it is necessary to understand the capability and design considerations to develop successfully with them.

We are going to analyse the different OSs to assess their pros and cons. This will help us to decide which OS we will use to develop the mobile app prototype for this project.

According to Leigh Shevchik there are three main mobile platforms: iOS (Apple), Android (Google and partners) and Windows Phone (Microsoft). [39] These OSs will be analysed and described below in order to understand the pros and cons of them to make a decision.

iOS or iPhone OS is from Apple Inc. It represents the second biggest installed base worldwide on smartphones, but the highest profits of any OS. It is closed source and proprietary and built on open source Darwin core OS. The Apple iPhone, iPod Touch, iPad and second-generation Apple TV all use iOS, which is derived from OS X.

Native third party applications were not officially supported until the release of iOS 2.0 on July 11, 2008. iOS 8 is the current version release in September 2014.

In 2014, the iOS global market portion was 14.8%. [39]

Additionally, Apple has focussed on the performance rather than appearance, since the basic appearance of iOS is nearly the same as it was in 2007. Nevertheless it is very user-friendly.

Android is the most popular mobile platform. It is an open source platform, where most applications are developed in Java through the official Android software development kit (SDK), this set of development tools provides software libraries, handset emulator based on QEMU, documentation, debugger, sample code, and tutorials.

Android's releases prior to 2.0 were used exclusively on mobile phones. Android 2.x releases were mostly used for mobile phones but also some tablets. However, Android 3.0 was a tablet-oriented release. The current Android version is 5.0. It was release in November 2014. [40]

Android increased its popularity due to its beautiful appearance and efficient working. Many new features were introduced and have played a significant role in Android's success.

Windows Phone is an OS developed by Microsoft. It is closed source and proprietary. It represents the third largest installed base on smartphones behind Android and iOS. It was first launched in October 2010 with Windows Phone 7.

This platform was inspired by the user interface in the Zune HD. The home screen, called the "Start screen", is made up of "Live Tiles", which have been the inspiration for the Windows 8 live tiles. Windows OS has been used in mobile phones but normal mobile phone users find it a bit difficult to operate it, but at the same time it was very popular among people who were used to it.

Microsoft release Windows Phone 8.1 in February 2014.

At the end of 2014, Windows Phone global market share was 2.7%. [39]

The following table shows a summary comparison between the three OS. [40]

Feature	iOS	Android	Windows Phone
Company	Apple Inc.	Open Handset Alliance/Google	Microsoft
Market share	15.00%	81.20%	3.00%
Current version	8.3	5.1.1	Windows Phone 8.1
Current version release dates	April 8, 2015	April 21, 2015	December 5, 2014
License	Proprietary EULA	Free and open-source	Proprietary
OS family	Darwin	Linux	Windows NT 8+[8]
Supported CPU architecture	ARM, ARM64	ARM, x86, MIPS and the 64-bit variants of all three	ARM

Programmed in	C, C++, Objective-C, Swift	C, C++, Java	7+: XNA (.NET C#), Silverlight, native C/C++ (only for vendors and partners[10]) Or 8+: .NET C#, VB.NET, Silverlight, native C/C++, WinRTP (XMLA), DirectX
Package manager	iTunes	APK	Zune Software (not since Windows 8)
Device independent system updates	No	No	Only for developers

Table 9 – Comparison of Mobile OS [43]

After analysing the different OSs we decided to use the Android platform for two reasons. First, this is an open source platform, so we don't need to concern about licenses and cost. Second, it provides developers with a software development kit to facilitate the app development. This includes a comprehensive set of development tools such as a debugger, wide software libraries, a handset emulator base, documentation, sample code, and tutorials.

3.7.2. Development strategy

For this research a mobile application has been developed to probe and analyse the solution suggested. The mobile channel was selected because the Flurry firm has reported stunning growth in mobile app usage in the last six years. According to Flurry Analytics, in 2014 overall app usage grew by 76%. Additionally, there are more than million mobile applications in Google Play and the iTunes App Store alike, and growth of those app marketplaces shows no sign of slowing down.

To create a Mobile App one of three approaches can be used when a mobile application is developed: Web apps, Hybrid Apps or Native apps.

Web Apps are websites designed to be displayed in mobile screens and accessed by typing a URL in the browser of mobile phones.

Hybrid Apps are Web applications that run inside a native package in a custom full-screen browser to resemble a native mobile app, the user interface is written in HTML/CSS and rendered by a web browser. A layer enables access to device capabilities that are not available in Web Apps, such as the camera and local storage.

Native Apps are written using a specific platform SDK, tools and languages, typically provided by the platform vendor. Native apps allow total access to the hardware and the UI is rendered by the platform SDK.

Currently, there are many mobile development tools available under open source licenses, and these tools continue to grow quickly. A review of the most popular tools were done to select the

tools that has been used to develop the event mobile application. From the previous review PhoneGap and Appcelerator Titanium tools were selected for a deeper analysis. After the analysis PhoneGap was selected to create the event mobile application.

PhoneGap and Appcelerator Titanium tools are very popular open source frameworks for creating and deploying mobile applications. These frameworks have reported many successful implementations on different platforms. However, there are important differences between them. The fundamental difference is that PhoneGap is a web-based solution while Appcelerator Titanium is a pure JavaScript API that creates native code.

There are more PhoneGap implementations than Appcelerator Titanium for a few simple reasons:

- ✓ Appcelerator lets developers use JavaScript to create a mobile application and compile down to native code for deployment. PhoneGap allows to utilize HTML5 standards to write your mobile applications and provide a JavaScript SDK to access native device capabilities. PhoneGap permits re-use the same code deploy with HTML5 across enterprise desktop apps, tablet, mobile and connected TV platforms.
- ✓ PhoneGap runs in a native web browser view using HTML5, CSS, and JavaScript, as well as all of the frameworks, like jQuery Mobile and Sencha. On the other hand, Appcelerator is pure JavaScript that compiles to Native Code.
- ✓ PhoneGap supports more platforms but Appcelerator may give you better performance in specific instances.
- ✓ PhoneGap clearly promotes the most re-use and provides the easiest transition from desktop to mobile.
- ✓ Appcelerator provides a better performance because it is compiled to native code.
- ✓ PhoneGap also supports deployments to more device platforms than Titanium because it doesn't need to compile to a native form. PhoneGap supports 7 mobile platforms": iOS, Android, Blackberry, Windows Phone, Palm WebOS, Bada and Symbian.
- ✓ Appcelerator is the first mobile platform to combine the flexibility of open source development technologies with the power of cloud services.
- ✓ Appcelerator supports Windows, Linux, OS X, iOS, Android operating systems, while for PhoneGap: Apple iOS, BlackBerry, Google Android, LG WebOS, Microsoft Windows Phone (7 and 8), Nokia Symbian OS, Tizen (SDK 2.x), Bada, Firefox OS, and Ubuntu are supported.
- ✓ PhoneGap permits the easiest transition from desktop to mobile.

In the following table presents a comparison of these tools:

Feature	PhoneGap	Appcelerator
Approach	Web App	Native App
Dev. Applications	HTML,CSS, JavaScript	JavaScript
UI Quality	Poor	Good
Truly Cross Platform	No	Yes

Performance	Decent	Good
Interaction	Limit Capabilities	Good
Support Operation System	All	Windows, Linux, OS X, iOS, Android
APIs	Common	Platform Specific
Code	Unique	Platform Specific
Code Layer	One	Two
Portability	Yes	No
Reusability	Total	Partial
Learning Process	High	Moderate

Table 10 – PhoneGap vs. Appcelerator

Both tools were tested and reviewed to decide which one to use to create the prototype. A simple program were developed using these tools. Appcelerator was easier to install, learn and developed the program. Additionally, the documentation available for this is better and wide.

To conclude PhoneGap was selected because it allow to re-use code across mobile, tablet, desktop and TV. The mobile performance is not a critical factor. Additionally, PhoneGap also supports deployments to more device platforms than Appcelerator because it doesn't need to compile to a native form.

3.7.3. Data Integration

First, let's define the two data sources used to show the events per city. The data form Barcelona is obtained from the **Open Data BCN Portal** via a file in XLM format. On the other hand the events from Lisbon, Helsinki, and Amsterdam are coming from CitySDK through the Tourism API (RESTful API). Both sources are described below:

- **Barcelona city events**

Kind of source: XML.

Link:
http://opendata.bcn.cat/opendata/es/catalog/LISTADO%20DE%20EVENTOS%20MENSUAL
City Events: Barcelona
Description: Cultural and Leisure Activities that will be celebrated or are celebrating in Barcelona.
License: CC BY 3.0
Update Frequency: Monthly
Data Structure: XLM format -> File was parse using DocumentBuilder java Library.

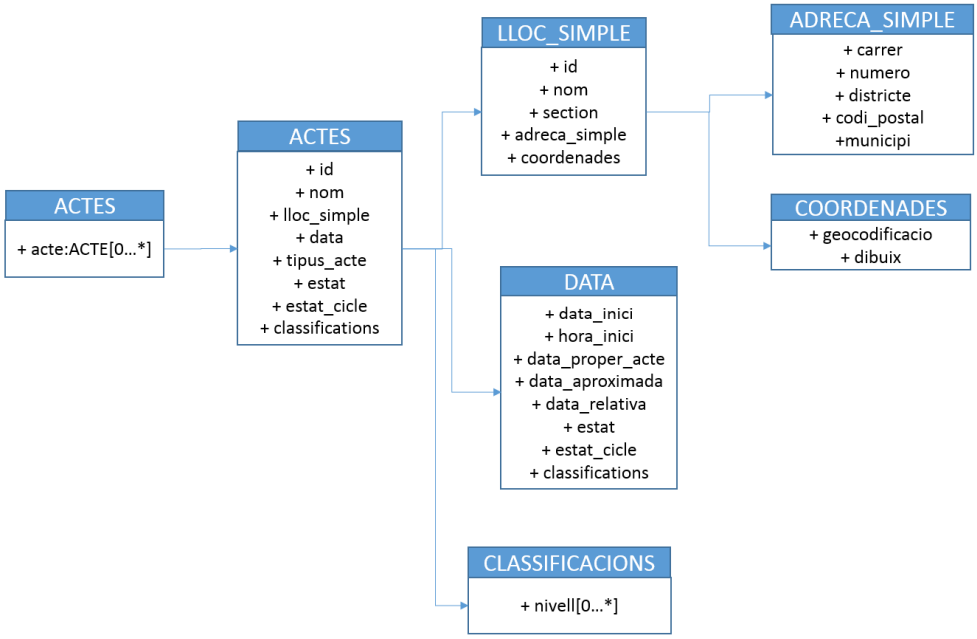

Figure 10: Barcelona XML data model

- **CitySDK city events**

Kind of source: Tourism API

Link: http://directory.citysdk.cm-lisboa.pt/pois/search?limit=-1
City Events: Lisbon, Helsinki, and Amsterdam
Description: description of all the events that are being or have been undertaken in Lisbon, Helsinki, and Amsterdam.
License: Associated to each POI – Usually is open-data
Update Frequency: Associated to each POI
Data Structure: W3C-POI WG. XML syntax for representing information about points of interest (POI) on the World Wide Web

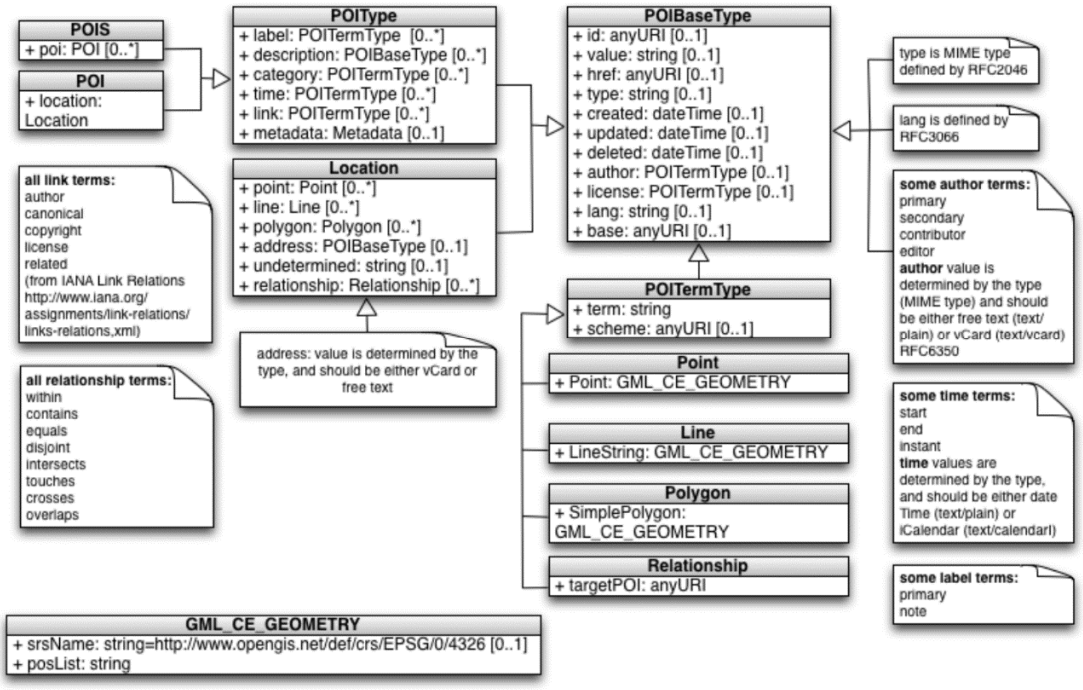

Figure 11: POI data model

As we can see in the sources data models both offer plenty of information, but the prototype uses a subset of this information. The prototype data model is based in the POI data model, since this syntax is well defined and it is supported by W3C institution, but it is quite simple since the information is transformed to a simple format to be displayed in a mobile device.

Below we can find a table with the data and the translation between the source data models and the prototype model.

Prototype Field	Type	BCN OD field	CitySDK field
`Id`	String	id	Id
`Label`	String	nom	Label -> value
`Description`	String	__	Description –> value
`Address`	String	Adreca_simple • Carrer • Numero • Districte • Codi_postal	Address –> value
`startDate`	String	data_inici	Time –> open - start

endDate	String	data_fi	Time – >open - end
Location	String	Adreca_simple –> coordenades –> geocodificacio • X – Latitude • Y - Longitude	`Location->Latitude` `Location -> Longitude`

Table 11 – Data Transformation

The following steps were executed to use the data in the prototype:

- **Data Extraction**

The data sources expose REST-style interfaces that return city event information when queried. The CitySDK interfaces expect a limited number of events and a start date. On the other hand, the BCN OD portal provides several XML files that are save in the local machine to be load.

The server side is responsible for understanding the differences in accessing the APIs of the sources as well as parsing the response data into intermediate Java objects. These objects will then be used in the next step.

- **Data Transformation**

Once data has been retrieved from the sources they have to be cleaned, normalized, merged and aggregated prior to persisting to ensure quality and consistency. As Event EveryWhere is primarily concerned with event details, so only the services that provides details are requested.

Thus events with no English description will be filtered out from CitySDK sources. Sources differ on how they represent location and dates events details from experience.

- **Data Load**

Once the final set of data has been determined after the transformation step, they are saved into memory. The city ids are used as keys. The rest of the data is stored as a JSON string.

3.7.4. Application Architecture

A four-layer architecture have been used to develop the prototype, in which the mobile app layer represents the interface or presentation tier, functional logic or business rules is represented by the service layer, the third layer is the data, where data access and transformation are developed and maintained as independent modules. The last layer covers the data Source that will be used to get the events details for the different cities.

The architecture for this app has been developed with object-oriented pattern.

Mobile app: is the top level of the application, which users can access directly. This tier displays information in a format that is easy to read for all users of a smart device. The layer communicates with the service tiers to get the results, which will be displayed in the app.

Service layer: The logical tier is pulled out from the previous layer and it controls the application's functionality by executing the different methods and functions to return the event list according to the city. A Dynamic Web Project was created to send the data to the mobile application.

Data access layer provides access to and transforms the data received from two data sources. This layer encapsulates the persistence mechanisms and exposes the data. Avoiding dependencies on the loading mechanisms permits updates or changes without the application layer being affected by or even aware of the change.

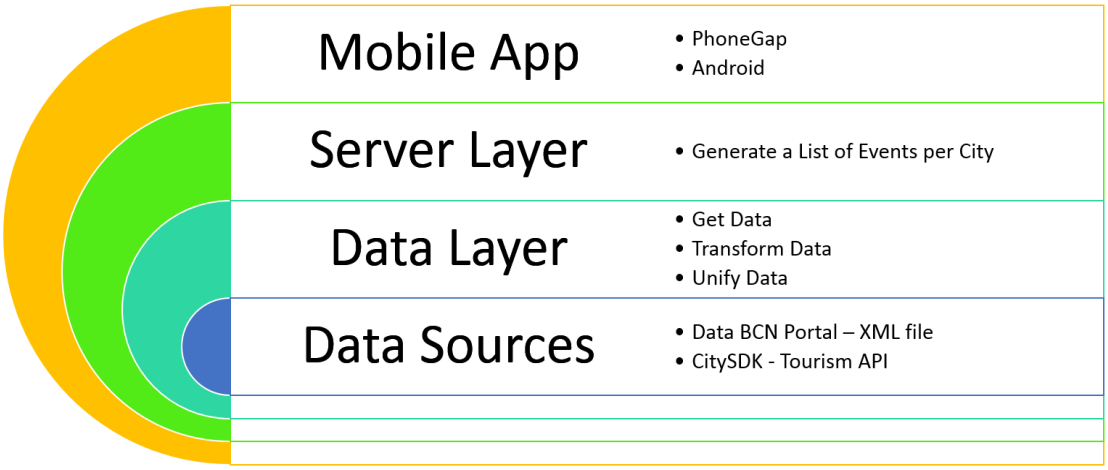

Figure 12: Architecture

The following deployment diagram displays the hardware components, the application server and the database server used for deployment the mobile application and how the different pieces are connected. Please find below the different components that integrated the system:

Event EveryWhere App – Users need to download and install the application in smart devices. The user can access it through the App icon.

Web Service – A dynamic web project was created with Jersey library to allow the mobile application get the list of events for each city. Three components are defined in the web service:

- Interface Layer – This class permits get the request from the different clients to provide the events for each city. This layer makes the changes in the service level be transparent for the clients.
- Load Data – Allows to load the different events per city in memory, so each request can be respond quickly.
- Data Base Interface –Get the events data per city

Data Server – This component is in charge to request the data from the two data sources to normalized and unify it according with the structure defined in table 11.

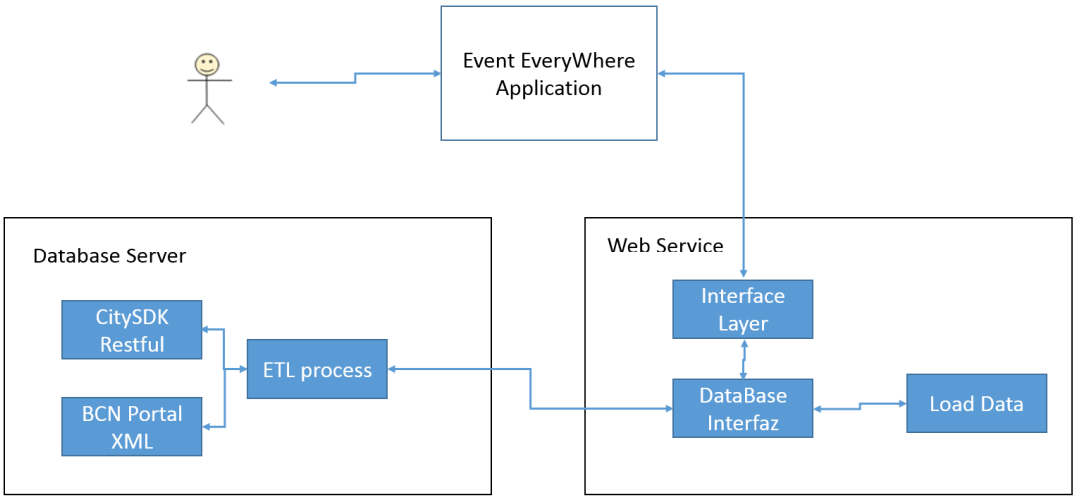

Figure 13: Deployment Model

3.8. Implementation

The following technologies were used to implement the prototype:

Java Development Kit (JDK) 8
Java JDK is a software development environment for writing Java applets and applications. It consists of a runtime environment that including the operating system layer as well as the tools and programming that developers need to compile, debug, and run applets and applications written in the Java language.

Android Software Development Kit
The official *Android* IDE and *developer* tools to build apps for *Android* phones, tablets, wearables, TVs, and more. It allows developers to create applications for the Android platform. The Android SDK includes sample projects with source code, development tools, an emulator, and required libraries to build Android applications which are written using the Java programming language. Android SDK is used as emulator to run and test the mobile application from Eclipse IDE.

CitySDK jar
The library contains three main classes. The TourismClientFactory, generates a TourismClient stub with the available server's dimensions. The TourismClient stub class allows the server to be queried for an individual or list of POI-based data. Lastly, the DataReader permits to further parse and get details from the returned data more quickly.

PhoneGap is an open source framework that allows you to create mobile apps using standardized web APIs for quickly building cross-platform mobile apps using HTML5, Javascript and CSS.

Android Developer Tools (ADT)

It is a *plugin* for the Eclipse IDE that prolongs the capabilities of this IDE. It offers developers access to features that facilitate development of Android applications such as quickly setting up new Android projects, creating an application UI, adding packages based on the Android Framework API and debugging the applications using the Android SDK tools. PhoneGap application provides different platforms and we have used Android one for the prototype.

HTML5
The mobile application is written in HTML5 and Javascript. It consists of an HTML file describing the layout of the mobile app and a Javascript file containing all the client-side scripting. The page contains of two principal menus. One option to select the current events cites and another menu option to select the international events data for Lisbon, Helsinki and Amsterdam.

Users can select a city and a list with the events details displayed for the current month.

Every time the user selects a different city, the script sends and asynchronous request to the web server asking for the data of the events in that particular city.

Representational State Transfer (REST) this architectural was used to define an uniform interface, which enable services to work best on the Web. The data events is accessed using Uniform Resource Identifiers (URIs), a links on the Web.

JSON Standard to transfer the data from the web service to the client.

Jersey Library - is open source, production quality, framework for developing RESTful Web Services in Java that provides support for JAX-RS APIs and serves as a JAX-RS

Prototype Screenshot

The following screenshot shows the mobile app with the different city event information obtained from CitySDK and BCN open data portal.

3.9. Prototype Screen Shots

The following screenshot shows the mobile app with the different city event information obtained from CitySDK and BCN

Figure 14: Deployment Model

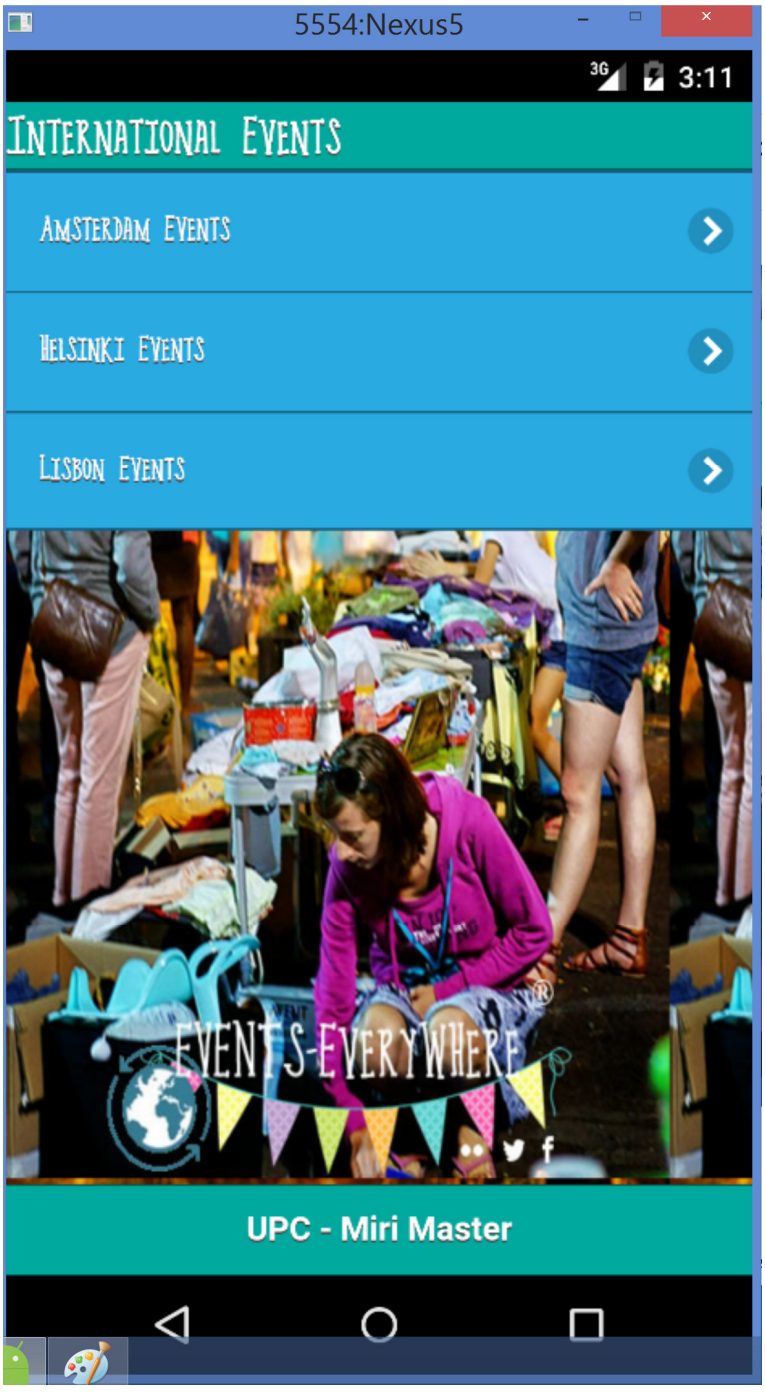

Figure 15: Development Model

3.10. Conclusion

After developing the Event EveryWhere mobile application, we achieved the following conclusions:

We have realized that the development to get the data through CitiSDK API was easy and faster than the one to get the BCN data, since they provide a library to access and transform the data in a simple a quickly way. Additionally it is more efficient because with can reuse the same code to get the events from different cities. Therefore the data transfer is very simple and direct.

Regard to the language, most of the relevant information such as category, label and description is advertised in the local language of the event's city, and so when this information is presented to the user and he or she doesn't speak the local language, the information is not completely understandable. City SDK syntax (W3C-POI) allows to define details in different languages, so we believe that data providers at least should include the events details in English as well.

We suggest make the description field in W3C-POI syntax a multilanguage attribute, since in this way we can provide a general idea of each event that can be understand by people with different language of the city's idiom where the event is going to take place.

The last but not the least recommendation is to create a catalogue for the category attribute, since this permits to classify and filter the events in a universal and easy way for all the cities.

3.11. Future Work

There are still possible areas for future work. The following mentions the most prominent ideas:

- Publish BCN city events following the syntax defined by CitySDK project.
- Analysis the CitySDK, iCity and FIWARE standards to evaluate and compare the performance, functionality, accessibility and reliability of these standards.
- Analysis possible solutions to solve the language issue.

APPENDICES

APPENDIX A

POINTS OF INTEREST, EVENTS AND ROUTES

Since the 3 resources inherit from the POI class, its properties are as follows:

- **base** – String – base URI of the POI;
- **id** – String – the ID of the POI;
- **lang** – String – the default language of the POI;
- **license** – POITermType – the license restrictions of the POI;
    - **term** – String – to discreminate multiple licenses (e.g.: common, opensource);
    - **value** – String.
- **author** – POITermType – the author of the POI;
    - **term** – String – to discreminate if the author is a primary, secondary, contributer, editor or publisher author;
    - **value** – String.
- **created** – Date – the date in which the POI was created (format: YYYY-MM-DD'T'hh:mm:ss.SSSSSSS'Z');
- **updated** – Date – same format as created;
- **deleted** – Date – same format as created;
- **label** – POITermType – a human-readable name of the POI. Multiple names are used for synonyms and multiple languages;
    - **lang** – String – the language of the label;
    - **term** – String – if it is the primary or secondary name;
    - **value** – String.
- **description** – POIBaseType – a human-readable description that can be discriminated with the language attribute;
    - **lang** – String;
    - **value** – String;
    - **type** – String – to discretize the type of description. Its values may be the following:
        - X-citysdk/price – containing, e.g., a price of entrance;
        - X-citysdk/waiting-time – indicating the waiting time in seconds;
        - X-citysdk/occupation – containing the occupation of the POI, between 0 and 100;
        - X-citysdk/accessibility-textual – accessibility information in human-readable format;
        - X-citysdk/accessibility-properties – containing machine-readable accessibility information.

      If this field is not present then, it is a description of the POI.

- **category** – POITermType – categorical classification of the POI;
    - **term** – String – either a category or a tag;
    - **value** – String.

- **location** – Location – provides information about the POI's location;

  Contains 0 or more of the following geometries:

- **point**;
  - **Point** – Geometry – a single point (latitude and longitude);
    - **srsName** – String – coordinate reference system;
    - **posList** – String – the coordinates set.
  - **term** – String – term used to describe this point. Recommended terms are: entrance, center, navigation point.
- **line**;
  - **LineString** – Geometry – a set of two points;
    - **srsName** – String;
    - **posList** – String.
  - **term** – String – term used to describe this line.
- **polygon**;
  - **SimplePolygon** – Geometry – a list of coordinates;
    - **srsName** – String;
    - **posList** – String.
  - **term** – String – term used to describe this polygon.
- **address** – POIBaseType – the civic address of the POI;
  - **type** – String – text/vCard;
  - **value** – String – address in vCard format.
- **relationship**- Relationship – establishes relations between POIs;
  - **term** – String – possible terms: equals, disjoint, intersects, crosses, overlaps, within, contains, touches;
  - **base** – String;
  - **targetPOI** – String – the ID of a Point of Interest; or **targetEvent** – String the ID of an Event.
- **time** – POITermType – a fixed time or sequence of times using iCalendar;
  - **term** – String – possible terms: start, end, open and instant;
  - **type** – String – text/calendar;
  - **value** – String – the time in iCalendar format.
- **link** – POITermType – a link to another POI or web resource;
  - **term** – String – possible terms: alternate, canonical, copyright, describedby, edit, enclosure, icon, latest-version, license, related, search, parent, child, historic and future;
  - **type** – String – the MIME type;
  - **href** – String – the absolute path of the link;
  - **base** – String;
  - **id** – String.

APPENDIX B

BCN MONTLY EVENTS STRUCTURE

```
  </info>
- <actes>
  - <acte>
      <id>99400320598</id>
      <nom>Taller 'Pilates i moviment'</nom>
    - <lloc_simple>
        <id>2011131453</id>
        <nom>Centre Cívic Cotxeres Borrell</nom>
        <seccio>#</seccio>
      - <adreca_simple>
          <carrer codi="361406">C Viladomat</carrer>
          <numero davant="0" enter="2*8">2</numero>
          <districte codi="02">Eixample</districte>
          <codi_postal>08015</codi_postal>
          <municipi codi="019">BARCELONA</municipi>
        - <coordenades>
            <geocodificacio x="30116662" y="81029541"/>
            <dibuix x="" y=""/>
          </coordenades>
        </adreca_simple>
      </lloc_simple>
    - <data>
        <data_inici>11/10/2014</data_inici>
        <hora_inici/>
        <data_fi>20/12/2014</data_fi>
        <data_proper_acte>25/10/2014</data_proper_acte>
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        <data_relativa/>
      </data>
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      </classificacions>
    </acte>
  + <acte></acte>
```

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